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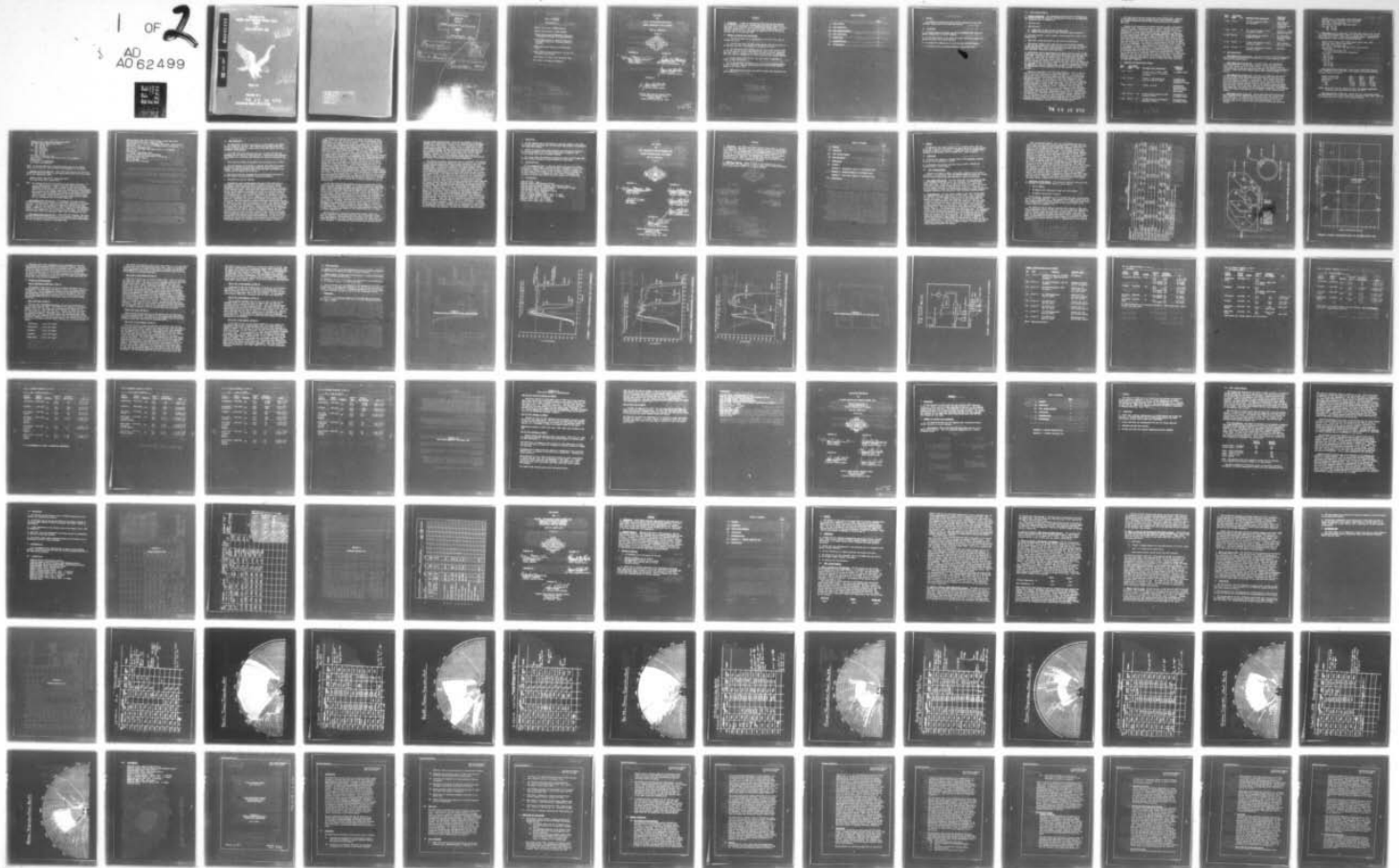
OFFICE OF THE PROJECT MANAGER CHEM DEMILITARIZATION I--ETC F/G 15/2  
DEMILITARIZATION PLAN OPERATION OF THE CHEMICAL AGENT MUNITIONS--ETC(U)  
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DRCPM-DRD-SP-77013

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②  
DEMILITARIZATION PLAN  
OPERATION  
OF THE  
CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM  
(CAMES)  
AT  
TOOELE ARMY DEPOT,

⑨ Final kept.

⑪ Mar 77

⑫ 159 p.

⑩ Alan A. Osgood

⑭  
DRCPM-DRD-SP-47013

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INCLOSURE NO. 6

Thermal Destruction of M25 Landmines

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Thermal Deactivation of Explosive Components  
of Chemical Munitions (Projectile Fuzes &  
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CANDS Deactivation Furnace Cyclone/Scrubber  
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Retort Blast Strength Calculation for Safe and  
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Pilot Test for Slagging Afterburner

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TEST REPORT

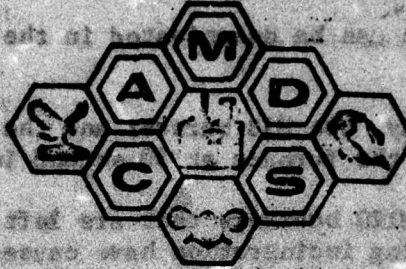
FOR

DB-93 - REACTIVATION FURNACE (REA)

THERMAL DESTRUCTION OF M3 LAMINATES

TEST NO. CAMS-03-2

18 Dec 74



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ABSTRACT

1. Background. In order to finalize the design of the mine machine, it is required to define the configuration that the M23 Landmine will have when it is incinerated in the Deactivation Furnace (DEA). The most desirable configuration is that requiring fewest dismantling steps in the mine machine and that can safely be incinerated in the DEA at the required rate of 40 mines per hour.

2. Summary of Results and Conclusions.

a. The M23 Landmine can be deactivated in the DEA at the rate of 40 mines per hour.

b. The M23 mine body, the M38 burster and the M120 booster have to be separated and fed to the furnace at 30 second intervals.

c. The RDX loaded M120 boosters that are left in the booster wells of the M38 bursters during incineration have caused pressure excursions that have varied in severity from barely audible reports to explosions that were severely damaging to the conveyor shrouds and furnace controls.

d. Tetryl loaded M120 boosters have been safely incinerated in place, in the M38 bursters.

e. In one instance, two M38 bursters have detonated simultaneously, in close proximity, without causing spalling or other visual physical damage of the retort shell.

f. RDX loaded boosters were successfully burned when separated from their bursters.

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**I. PURPOSE.**

To define the configuration that the M23 Landmine will have when thermally deactivated in the CAMDS DEA furnace.

**II. OBJECTIVES.**

- A. To define furnace conditions and M23 mine configuration that will permit incineration of the M23 Landmine.
- B. To test the ability of the input and output conveyor to handle M23 mines at the rate of 40 units per hour.
- C. To measure the temperature at which the mine exit the furnace.
- D. To measure furnace operating parameters during mine burns.

### III. TEST ACCOMPLISHMENTS.

A. General Background. The nomenclature defining the M23 landmine does not specify either its stockpile configuration or that of its components. The stockpiled mine is composed of:

1. M23 mine body
2. M48 initiator
  - a. loaded with 55 grams of Comp B4 after 1965
  - b. loaded with tetryl prior to 1965 (probably similar quantity).
3. M-1 side activator, tetryl loaded, stored separately in cans in the shipping drum
4. M503 fuse, stored separately in cans in the shipping drum
5. M38 burster, having 0.82 lb Comp B4 and a tetryl pellet oriented to face the M48 initiator and held externally in a side well by adhesive backed aluminum foil. Some of the bursters have steel cases but most have fiberglass reinforced polystyrene cases.
6. M120 booster having approximately 10.3 grams of either tetryl or RDX. Tetryl was used prior to 1956, and Comp A5 (98.5% RDX, 1.5% wax) was used after 1956. From these M23 landmine tests it appeared that the M120 boosters at Tooele that were tetryl loaded were with plastic cased M38 bursters and the RDX loaded boosters were with steel cased bursters. This was erroneously believed to always be the case, but is not necessarily so, and might be just an isolated case. It should be noted that there is no nomenclature change to differentiate between the explosive fill of the two M120 boosters or M48 initiators or the case material of the M38 bursters.

During the mine tests, the retort was operated at 1 RPM, it was lit manually and the afterburner was controlled manually. The horizontal part of the Teller Cross Flow scrubber was empty of its packing except for the two sections which were filled with approximately one foot of Tellerette packing. It was found in a later test (CAMDS-03-4) that because of a leak in the pipe leading to the spray nozzles, the demister section was actually being flooded with water. This probably caused the heavy entrainment of water up the stack during the mine test and the previous rocket burn (CAMDS No. 03-1). Isokinetic flue gas sampling was carried out by STW Testing Inc., per EPA methods, at the horizontal duct between the furnace and the afterburner. Details can be found in "Particulate Emission Tests, CAMDS Furnace Site", Vol II, dated 9-23-74, STW Testing Inc. Pertinent STW has been included herein, together with the STW run number for ease in cross reference. Several runs will not have any STW data because they were aborted because of some furnace or conveyor malfunction before sufficient sampling time was logged to constitute a meaningful traverse of the duct being sampled.



The mine test series was divided into three natural parts, separated by two catastrophic pressure excursions that caused extensive damage to the conveyor shrouds or furnace Hauck valve and resulted in extended down time.

Because of the uncertainty of events occurring inside of the furnace, the general term "pressure excursion" is used to describe the whole range of transients, from barely audible reports, through mild low order deflagrations, to high order extremely violent detonations. Even when described in technical manuals the terminology describing fast reactions is both broad in scope and leaves large undescribed gaps. FM5-25 defines low order deflagrations to have propagation rates of 400 ft/sec to 1300 ft/sec and high order detonations to vary from 3280 ft/sec to 27900 ft/sec. This leaves wide, undefined gaps below deflagration and between deflagrations and detonations. The trade-off between quantity and rate of reaction must also be addressed. Any pressure excursion (report, "pop", "bang") can be the result of either a slow reaction of a large quantity of explosive or alternately of a fast reaction of a very small quantity of explosive. Specifically, with the mine burns, it is never known how much of the Comp B4 has burned before the rest is initiated by the RDX booster. This is why the description of transients within the furnace have to be always very subjective, and often less precise than would be desirable. When deflagration is used, the steel case of the M38 burster was found. Detonation describes explosions sufficiently severe to shatter the steel case into unrecognizable fragments.

#### B. Tabulated Test Description Summary.

<u>DATE</u> 1974	<u>RUN NUMBER</u> <u>CAMDS</u>	<u>STW</u>	<u>Summarized Test Description</u>	<u>Summarized Results</u>
5 Apr	03-2-1	-	1st mine burn, 9 mines, w/M48 initiator @ 600°F, no booster, no burster.	No audible report
8 Apr	03-2-2	-	6 mines, 6 RDX boosters in place in bursters @ 600°F	3 audible but nondestructive pressure excursions
9 Apr	03-2-3	-	3 mines, as above	Deflagration destroyed Hauck valve, UV sensor, MHE shrouds
1 May	03-2-4	34A	12 RDX boosters separated from bursters @ 600°F	Controlled burn, no audible report
3 May	03-2-5	35	100 RDX boosters, 100 bursters separated, @ 600°F	Controlled burn, no audible report



<u>DATE</u> 1974	<u>RUN NUMBER</u> CAMDS	<u>STW</u>	<u>Summarized Test Description</u>	<u>Summarized Results</u>
6 May	03-2-6	-	50 tetryl boosters @ 300, 600 and 800°F	Only 15% burn @ 300, 100% controlled burn @ higher T
7 May	03-2-7	36	100 tetryl boosters in place in bursters @ 600°F	Good burn. Slight report @ 83rd one
10 May	03-2-8	-	6 RDX boosters in place in bursters @ 300°F	two detonations, extensive damage to system
17 Jun	03-2-9	-	4 mines, RDX booster, burster separated @ 600°F	Inlet conveyor jam, test aborted
18 Jun	03-2-10	-	65 mines, RDX booster, burster separated, 600°F	Good burn

### C. Test Description.

Test Number 03-2-1 (5 Apr 74). Nine mine bodies with M48 side initiators but containing no bursters were incinerated at a furnace setting of 600°F. There was no audible report.

Test Number 03-2-2 (8 Apr 74). Six mine bodies, each followed at 45 second intervals by an M38 burster having a steel case and an RDX filled M120 booster were fed to the furnace. The M120 boosters were in their wells and so were the side tetryl pellets. The furnace was controlled at 600°F. There were three audible reports which caused no damage to the system.

Test Number 03-2-3 (9 Apr 74). The same test conditions were used as the previous day; mines and unseparated booster/burster were fed at 45 second intervals to the furnace set at 600°F. After feeding three mines but before feeding the fourth, a deflagration near the feed end of the retort not only tore off the shroud of the input conveyor but also tore the cover of the output conveyor. Most of the physical damage was caused when this cover fell on the Hauck valve and on the UV sensor and damaged both beyond use. The furnace and the afterburner flamed out. The auxiliary blower inlet damper was blown out of its hinges, but the ducting was not damaged.

Test Number 03-2-4 (1 May 74). Twelve RDX loaded M120 boosters and their separated steel cased M38 bursters were fed to the furnace at 45 second intervals. No audible reports was experienced during this test. The steel cases of the bursters were recovered undamaged. The thin aluminum cases of the boosters were also recovered indicating controlled burning.



**Furnace Control Temperature, 600°F (680°F peak)**

**Skin temp, burner end 500°F, stack end 300°F**

**Flow rate in horizontal duct:**

**34.3 ft/sec, 2630 ACFM, 1210 SCFM, 495°F**

**NO<sub>x</sub> Avg 100 ppm**

**Max 160 ppm**

**Min 40 ppm**

**Test Number 03-2-5 (3 May 74).** 100 steel cased M38 bursters and 100 RDX loaded M120 boosters (lot: LOP-6-1, 10-56) were fed to the furnace at 30 second intervals. There were no audible reports. Inspection of burster/booster cases indicate controlled burning.

**Furnace Control Temp, 600°F (680°F peaks) burner temp, 200°F**

**Skin temp stack 490°F, burner 460°F**

**Flow rate in horizontal duct:**

**57.6 ft/sec, 4040 ACFM, 1800 SCFM 530°F, 2.6% Moisture**

**Emission Rate**

**1.26 lb/hr particulate only**

**1.56 lb/hr particulate plus condensibles**

**NO<sub>x</sub> (TECO)**

**Avg 90 ppm**

**Max 155 ppm**

**Min 50 ppm**

**NO (TECO)**

**Avg 65 ppm**

**Max 105 ppm**

**Min 30 ppm**

**Test Number 03-2-6 (6 May 74).** Fifty tetryl loaded M120 boosters (lot: LOP-1-36, 12-51) were fed to the furnace at 30 second intervals at three temperature levels.

<b>Furnace Control Temp</b>	<b>300°F</b>	<b>600°F</b>	<b>800°F*</b>
<b>Furnace Actual Temp</b>	<b>300°F</b>	<b>600°F</b>	<b>740°F</b>
<b>Burner Temp</b>	<b>200°F</b>	<b>250°F</b>	<b>280°F</b>
<b>NO<sub>x</sub> Avg</b>	<b>35 ppm</b>	<b>150 ppm</b>	<b>165 ppm</b>
<b>Max</b>	<b>80 ppm</b>	<b>220 ppm</b>	<b>235 ppm</b>
<b>Min</b>	<b>20 ppm</b>	<b>50 ppm</b>	<b>55 ppm</b>

**\*NOTE:** While 800°F was the temperature goal, the maximum temperature obtainable with Hauck valve wide open was 740°F.

**Test Number 03-2-7 (7 May 74).** During this run, one hundred plastic M38 bursters with their tetryl loaded M120 boosters in place (lot: LOP-1-36, 12-51) were fed to the furnace at 45 second intervals.



Furnace Control Temp 600°F, Burner Temp 280°F  
Skin Temp, Stack 550°F, Burner 480°F

NO<sub>x</sub> Avg 100-125 ppm

Max 280 ppm

Min 60-75 ppm

NO Avg 75-100 ppm

Max 170 ppm

Min 30 ppm

Flow rate in Horizontal duct:

54.7 ft/sec, 4200 ACFM, 1880 SCFM @ 524°F & 2.3% Moisture

Emission Rate

2.19 lbs/hr w/o condensibles

2.51 lbs/hr w/condensibles

NOTE: Of the 100 unseparated boosters/bursters there was an audible report at the 83rd one. This was mild and nondamaging to the system

Test No. 03-2-8 (10 May 74). Steel cased M38 bursters with their RDX loaded M120 boosters in place (in the booster well) were fed to the furnace set at low temperature, 300°F.

Furnace Control Temp 300°F, Burner Temp 310°F

Skin Temp Stack 220°F, Burner 300°F

NOTE: Six bursters were fed to the furnace at one minute intervals. At 4 & 4.5 minutes after the start of the test there were two non-damaging deflagrations. After 5 minutes a third and much louder detonation at the feed end of the retort damaged the conveyor shroud. After a total of six minutes running time, an explosion, considerably more severe than the previous one occurred at the burner end of the furnace and caused extensive damage to the outlet conveyor, Hauck valve, UV sensor, furnace seals, auxiliary blower duct and damper. Both the afterburner and the furnace flamed out.

Test Number 03-2-9 (17 Jun 74). M23 landmines, M38 steel bursters and M120 RDX boosters were to be fed to the furnace separated at 30 second intervals. The fourth mine jammed and damaged the damper of the input conveyor. This let cold outside air to flow over the controlling thermocouple. Temperature fell from 600°F to 400°F. Reacting to the temperature controller the furnace went on a continuous high fire mode. The test was aborted because effective temperature control over the furnace was lost.

Test Number 03-2-10 (18 Jul 74). Sixty-five M23 landmines, M38 steel bursters and M120 RDX boosters were fed to the furnace at 30 second intervals with the furnace and afterburner set at 600°F and 1200°F respectively. All data indicated a satisfactory controlled burn.



Furnace Control Temp 600°F (660°F spikes), Burner Temp 390°F  
 Skin Temp Stack End 440°F, Burner End 600°F  
 Burner Draft - 0.13 in w.c., Horizontal duct draft - 0.61 in w.c.  
 Afterburner draft - 1.4 in w.c., Scrubber Draft - 9.8 in w.c.  
 Flow rate in horizontal duct:  
 62.9 ft/sec, 4830 ACFM, 2180 SCFM @ 520°F & 3.1% Moisture  
 Emission rate  
 2.78 lbs/hr, particulates only  
 3.21 lbs/hr, particulate and condensibles  
 Anderson Particle Size Distribution (STW run 38)  
 20% smaller than 1 micron  
 50% @ 5 microns  
 20% greater than 10 microns

Flow rate in horizontal duct  
 62.9 ft/sec, 4830 ACFM, 2180 SCFM @ 520°F & 3.1% Moisture  
 Emission Rate  
 2.78 lbs/hr particulates only  
 3.21 lbs/hr particulate and condensibles  
 Anderson Particle Size Distribution (STW run 38)  
 20% smaller than 1 micron  
 50% @ 5 microns  
 20% greater than 10 microns

NOTE: Of the 100 unseparated particulates there was an analysis report at the 83rd one. This was mild and nonhazardous to the system.

Test No. 02-2-8 (10 May 78). Steel lined MIO burners with their RDX loaded (RDX burners in place for the burner well) were fed to the furnace at low temperature, 300°F.

Furnace Control Temp 300°F, Burner Temp 310°F  
 Skin Temp Stack 120°F, Burner 300°F

NOTE: Six burners were fed to the furnace at one minute intervals. At 4.2 minutes after the start of the test there were two non-damaging deflagrations. After 5 minutes a third and much louder deflagration at the feed end of the reactor damaged the conveyor through. After a total of six minutes running time, an explosion, considerably more severe than the previous one occurred at the burner end of the furnace and caused extensive damage to the outlet conveyor, Hatch valve, UV sensor, furnace seals, auxiliary power unit and burner. Both the afterburner and the furnace flamed out.

Test Number 02-2-9 (11 May 78). MIO burners, with steel burners and MIO RDX burners were fed to the furnace separated at 30 second intervals. The fourth mine burned and damaged the burner of the furnace. This led to a cascade fire to the rest of the controlled furnace. Temperature fell from 600°F to 400°F. According to the temperature controller the furnace went on a nonfunctioning high fire mode. The test was aborted because effective temperature control over the furnace was lost.

Test Number 02-2-10 (18 May 78). Five five MIO burners, MIO steel burners and MIO RDX burners were fed to the furnace at 30 second intervals with the furnace and afterburner set at 600°F and 1500°F respectively. All data indicated a satisfactory controlled burn.



#### IV. TEST EVALUATION

A. The feasibility of safely deactivating the M23 Landmine was demonstrated in Test No. 03-2-10. This required that the RDX loaded M120 booster be removed from the booster wall of the M38 burster and be fed separately to the furnace.

B. Both input and output conveyor were able to handle the M23 mine components at the rate of 40 mines per hour. After having been modified, the conveyor is considerably more reliable but cannot be considered jam free.

C. Mines exit the furnace at 500-600°F with the furnace set at 600°F.

D. With the furnace set at 600°F, it produces 4830 ACFM of flue gases containing 3.2 lbs/hr of particulate having an average diameter of 5 microns. Of this distribution, 20% of the particles were smaller than 1 micron and 20% larger than 10 microns.

E. The retort walls were undamaged by the simultaneous detonation of two M38 bursters within sympathetic detonation proximity.

F. Discussion and Failure Analysis.

Although the tests accomplishments were met in the tenth test, a discussion of possible failure modes of previous tests is necessary. The severity of the explosions can be related to the extent of the deformation of the steel cases of the M38 bursters which can be deformed in two different areas. The booster wall which hold the RDX loaded M120 booster can be completely undamaged and retain its cylindrical shape if the RDX merely burns. As the reaction increases in severity the sides of the booster wall can be slightly bowed out or be distended to several times of the original size, or as a limiting condition, can be completely blown out. Similarly, the apex of the truncated cone containing the Comp B4 can vary from slightly to severely distended depending on the rate or quantity of Comp B that is initiated by the RDX. The limiting condition in this case has been the total shattering of the burster body into fragments too small to be identifiable. Factors controlling the severity of the booster wall deformation are not completely known; but Dr. Matsugawa of Picatinny Arsenal and Dr. Katsanis of Edgewood Arsenal, who were consulted after the first incident, indicated that the RDX is more temperature sensitive than the tetryl booster and that raising the temperature increases the chances of high order reactions. In the case of the deformation of the conical body of the M38 burster it is felt that the quantity of Comp B4 left unburned at the instant of initiation by the RDX probably controls the severity of the total pressure transient.



A discussion of specifics of both the first and second incidents (CAMDS -03-2-3 and -03-2-8) required the general consideration of the separation of the items within the furnace. The present deactivation furnace has four sections, each having two complete spirals, hence the total retort can be regarded as being divided into eight compartments. Since the retention time is eight minutes at one RPM, each compartment travels its own width forward in one minute, i.e., it comes under the feed chute for a period of one minute. Theoretically, items would have to be fed at more than one minute intervals to be separated by one of the spiral ribs in the furnace. In actuality this time has to be increased by probably 50% to account for the possibility of an item falling on top of a rib and rolling one way and the next item also falling on top of a rib but rolling the other way. This might explain the uneven rate at which items exit the furnace, or even pass each other in the furnace. During the 8 April test (#03-2-2), mines and bursters were fed to the furnace at 45 second intervals. Initial field inspection of the one deformed mine showed it to be blown as if pressurized by an internal charge, in this case, by the side initiator. More careful inspection at AEO showed that this was not possible since the walls of the side initiator were intact. The mine therefore had to be pressurized by a charge external to it, but in close contact with it. Hence it was theorized that the mine must have fallen on a burster that had been in the retort for 45 seconds and had become sensitized by this time-temperature combination. In this case, the possible cause of failure has to include physical as well as thermal shock.

In the case of the 10 May incident, of the six bursters fed to the furnace one was recovered undamaged, two slightly damaged and three were never recovered although the retort was operated until it was completely empty. These three cases must have disintegrated into fragments too small to be identifiable. There was one fewer report than bursters fed to the furnace. This, coupled with the fact that the last explosion was much louder and much more severe than the previous one indicates that this last explosion near the burner end of the furnace was in reality a sympathetic detonation of two bursters in close proximity within the same flight of the retort. This was possible since the feed rate was one per minute. Although this detonation caused extensive damage to the material handling system it caused no visual damage to the wall of the retort itself. If there had been any physical damage to the retort, it would have shown up during the following high temperature burns, when the end of the retort was exposed to wall temperatures well in excess of 1100°F. (CAMDS 03-3)

The incineration of the tetryl loaded M120 boosters showed that 300°F is clearly an insufficient heat level (only 15% burned) and that 600°F was adequate. M38 bursters were incinerated with their tetryl loaded M120 boosters in place. There are, however, two reasons why this is not desirable. A mild pressure excursion was heard near the end of



the test (83rd burster burned). Since this is possible, it must be assumed that a more severe reaction is not impossible and that damage to the furnace could result. Another reason for separating the M120 boosters is the uncertainty of whether or not a burster has an RDX or tetryl loaded booster. Of the lots that are at Tooele Army Depot it was originally thought that those with steel cased bursters have RDX boosters and those with plastic cased bursters have tetryl loaded boosters. However it has been recently learned that this is not always the case. Due to lack of specific nomenclature differentiation, the content of the booster cannot be readily identified.

The problem of conveyor malfunction must be considered. The addition of a reverse jog switch has enabled the test personnel to deal with most conveyor jam-ups before their effects become irreversible and cause aborted tests. To become more effective, the input conveyor should be equipped with a sensor (I.R., proximity) to enable detection of a jammed item between the conveyor's outlet and the furnace inlet. Failure to detect an obstruction results in the whole feed chute filling up before the conveyor stops. This condition cannot be cleared by the reverse jog mechanism. In all but one case this has resulted in test cancellations. This is particularly distressing when the malfunction occurs near the completion of a test being carried out with an item that is in short supply; in this case, mines having bursters containing RDX loaded boosters. The outlet conveyor can more often be cleared by the use of the reverse jog mechanism. This conveyor is much more prone to stoppage because the problem is inherent with its design. The mechanism of a malfunction is as follows. When an item, e.g. a mine, falls from the furnace outlet, and if its horizontal dimension is close to that between two vertical members of the conveyor, such as between two consecutive flights, or a flight and a bolt, there is no problem while the conveyor motion is horizontal. When the motion of the conveyor changes from horizontal to inclined upward, the conveyor assumes the shape of a curve and the mine becomes its cord. Since the cord is always shorter than the arc of the curve it subtends, the obstruction is placed in compression, it either bends or stalls the conveyor. Until this "arc/cord" effect is designed out of the outlet conveyor, stoppages can be anticipated in future tests. In approximately two thirds of the cases the stoppages have been cleared with the reverse jog mechanism, the rest have required manual clearing.



## V. CONCLUSIONS.

- A. The M23 landmine can be deactivated in the test furnace at the rate of 40 mines/hour providing that the RDX loaded M120 boosters are separated from their M38 bursters.
- B. Failure to separate RDX loaded boosters from bursters has resulted in several explosions that have been particularly damaging to the furnace burner valve and the conveyor shrouds.
- C. The retort shell has suffered no spalling or other visual damage when two M38 bursters detonated in close proximity of each other.

## VI. RECOMMENDATIONS.

It is recommended that: 1) the mine machine be modified to enable separation of M120 boosters from M38 bursters, regardless of their type of explosive loading, 2) an IR sensor be added to detect stoppages in the feed chute of the furnace, 3) the "cord/arc" effect be designed out of future conveyors, 4) a Niagara oil water (\$140) be purchased and installed in the oil feed line to the test furnace, for future tests.

## VII. DISTRIBUTION.

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TEST REPORT

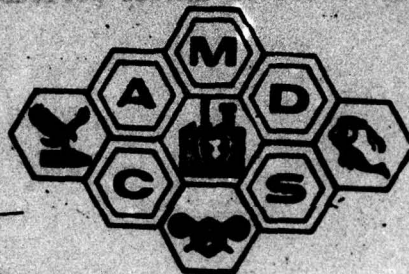
FOR

MS-6 DEACTIVATION FURNACE NUMBER (MFS)

THERMAL DETOXIFICATION OF MS5 ROCKETS

TEST NO. CAMD 03-3

14 Apr 75



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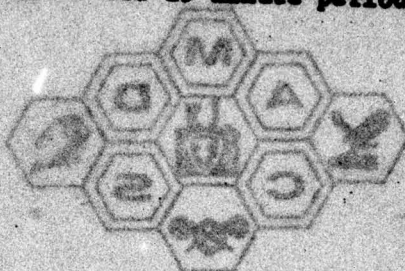


# ABSTRACT

THOMAS J. VINT

1. Background. The CAMDS Deactivation Furnace System (DFS) is designed to detoxify non-combustible munition components as well as inactive explosive components. The pilot plant tests reported herein were conducted to verify that thermal detoxification of non-combustible components can be achieved at the 1000°F operating temperature of the DFS and to determine the residence time required. The aluminum case and the fiberglass reinforced plastic (FRP) tubes of the M55 Rocket were selected as representative samples of non-combustible components.

2. Summary of Results. Sample sections of the aluminum body and of the FRP rocket tube immersed for a week in agents GB or VX were detoxified after being heated to 1000°F for 15 minute periods.



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## **I. PURPOSE**

To determine that sample sections of the aluminum rocket case and of the FRP rocket tube contaminated with agents GB and VX can be thermally detoxified at 1000°F as described in "CAMDS Test Plan for Thermal Detoxification of M55 Rockets, Test No. CAMDS 03-5", dated 10 Jan 75.

## **II. OBJECTIVES**

- A. To verify that samples of the M55 rocket system immersed in agents GB and VX can be detoxified at 1000°F.
- B. To determine the minimum residence time at 1000°F required for detoxification of either agents.

## **III. TEST ACCOMPLISHMENTS**

Samples were soaked in agent, incinerated, removed from the furnace and placed in covered pails. Air was passed through the pails and through bubblers whose solution was then analyzed for agent concentration.

A. Test Sample Description. The test items were one inch long sections of the aluminum rocket case and of the fiberglass reinforced plastic (FRP) launch tube. These are 4.42 and 4.89 inches O.D. respectively. A Refrasil covered chromel-alumel thermocouple was fastened to the inside of the aluminum ring with an aluminum strip, (Fig 1a). Originally it had been planned to insert the thermocouple between the rings, insufficient clearance resulted in the selection of this alternate fastening method.

B. Detail-General. The test pieces, together with their thermocouples were immersed in either agents VX or GB for a week. Prior to the start of each test, the pilot plant furnace of lab 1C, Bldg 5625, Edgewood Arsenal was brought to 1000°F and maintained at this temperature for 5 minutes nominal after which the flame was turned off. Two test items (rings) were removed from their conditioning containers and suspended on buret clamps held on a ring stand in the furnace. The rings were approximately 12" above the oven floor, their open ends were facing the burner, (Fig 1b). The thermocouples were connected to a dual channel recorder, the furnace door was closed and the burner relit. The temperature of the rings was maintained manually at or near 1000°F for the prescribed period of the test after which the flame was extinguished and the test rings were removed from the incinerator. The actual Time-Temperature Profile for individual rings during each test is given in Appendix 1. These profiles show the difficulties in maintaining the samples at the nominal 1000°F level. A visual estimate of the deviation from the desired temperature program was made and is given in Table 1, in most cases the actual exposure exceeded the nominal.



After thermocouple removal, each test ring assembly was placed in a pail whose lid was either taped or crimped shut. On each pail there were soldered two copper tubing nipples approximately 1/4"D x 2"L, located on the cylindrical part of the pail, radially oriented, and diametrically opposite from each other. Their purpose was to enable fresh air to be drawn over the sample ring and passed through bubblers designed to collect any agent that might have been in the air stream. Each pail was connected to two bubblers in parallel, each having a calibrated orifice designed to split the air stream in half, a typical arrangement is shown in Appendix II, Fig 1. For this test series, air was drawn through the pails by a vacuum pump at 2 liters/min, for two hours, for a total of 120 liters through each bubbler. The bubblers contained 15 ml of 0.001N H<sub>2</sub>SO<sub>4</sub> solution and were kept in ice baths during testing and until analyzed for agent concentration by enzyme titration. The nanograms of agent per 15 ml of bubbler solution were converted to the equivalent concentration of agent in the 120 liters of air passed through each bubbler. Results are given in Table 1 and in Figure 2. Table 1 also gives the agent concentration of bubblers from other sample locations such as blank pails, scrubber, incinerator or ambient air in the test capsule. Figure 2 also gives these test results and minimum detectable levels of specific GB and VX enzyme tests.

C. Comparison of Test Groups. The results of this test series can best be evaluated as three distinct groups of data, namely:

1. The VX samples
2. GB samples with incineration times up to five minutes
3. GB samples incinerated 15 minutes

The VX samples, incinerated 2 and 15 minutes were below the detectable level of the enzyme analysis. These results are straight forward since all the thermally detoxified samples analyzed below the detectable level while other samples such as those monitoring the air in the capsule or the scrubber showed the presence of VX.

The results of the GB samples incinerated five minutes or less need some interpretation since, in each case, one of the duplicate samples was "clean" while the other one definitely contained agent. Both bubblers from the "clean" sample had agent below the detectable level while the agent in the contaminated bubblers was several orders of magnitude higher. While the difference in duplicate samples cannot be explained it must be concluded that 5 minutes residence time is insufficient to assure detoxification.

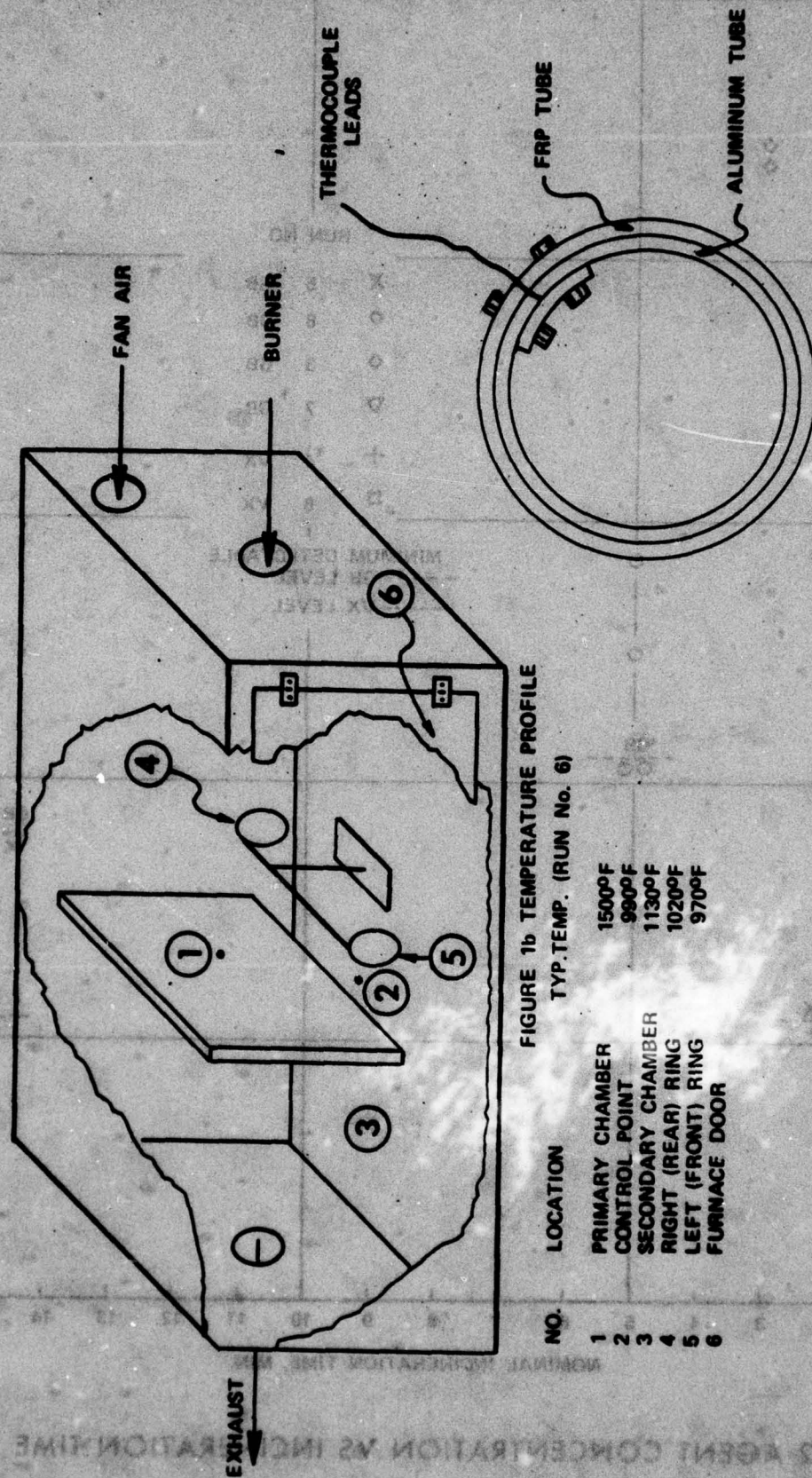


TABLE 1  
TEST RESULTS  
CHANGE IN AGENT LEVEL WITH DECREASING INCUBATION TIME

Incubation time nominal, min.	15	5	3	1	15	2
Run Number	5 (GB)	8 (GB)	3 (GB)	7 (GB)	6 (GX)	4 (GX)
Sample Location (1)	L	L	L	L	L	L
Agent in Bubbler	47.5	47.5	3360	30	41.5	41.5
mg/lb ml	47.5	9.0	2335	34	41.5	41.5
Agent in Air Sample (3)						
mg/m <sup>3</sup> x 10 <sup>-4</sup> (v/l x 10 <sup>-4</sup> )	<0.625	<1.24	280	2.5	<0.125	<0.125
Agent in Air Sample	<0.625	<1.24	236	2.83	<0.125	<0.125
Blank - mg/m <sup>3</sup> x 10 <sup>-4</sup>	<0.625	<1.24	-	<0.67	<0.125	-
Agent in Air Sample	<0.625	2.06	-	<0.67	<0.125	-
Scrubber mg/m <sup>3</sup> x 10 <sup>-4</sup>	23.9	118	110	23.9	20.7	<0.118
Agent in Air Sample	20.3	87.5	121	16.6	22.6	<0.118
Incinerator, mg/m <sup>3</sup> x 10 <sup>-4</sup>	7.77	5970	0.57	1900	3.02	0.313
Agent in Air Sample	5.17	5560	10.3	1273	3.45	0.952
Capsule, mg/m <sup>3</sup> x 10 <sup>-4</sup>	8.17	-	-	43.2	0.575	-
Total Time, min	15	15	5 1/2	15	12	2
8 Ave Temp, °F (6)	975°F	950°F	1050°F	1050°F	930°F	1100°F
Time, min.	15	15	15	15	15	15
8 Max Temp °F (6)	1130°F	1020°F	1140°F	1050°F	1150°F	1150°F
Pail Closure	crimped	crimped	crimped	crimped	crimped	crimped
Pail Location (2)	outside	outside	inside	inside	outside	inside

NOTE 1 - Sample Location. Right or left ring, see Fig 1b  
 2 - Pail location inside capsule or outside, in pilot plant atmosphere  
 3 - Agent concentrations, mg/m<sup>3</sup> x 10<sup>-4</sup> = v/l x 10<sup>-4</sup>  
 4 - In most cases Time-Temperature exposure exceeded the nominal conditions





ROCKET SECTIONS ASSEMBLY  
Fig. 1a

FIGURE 1 LOCATION OF ROCKET SECTIONS IN FURNACE





The third group to be considered is that containing the two pails whose samples were exposed to GB and incinerated 15 minutes. The two bubblers from one pail were below the detectable level,  $<7.5 \times 10^{-4}$  ng/15ml. One of the bubblers from the second pail was also at  $<7.5 \times 10^{-4}$  ng/15ml. The second bubbler from this pail analyzed at  $9.0 \times 10^{-4}$  ng GB/15 ml and since the discrepancy is at the lower threshold limit of detectability the anomaly is interpreted as being the result of interferences with the enzyme test rather than GB contamination.

#### D. Details of Individual Runs.

##### Run 1, Preliminary Blank Run, 4 Feb 75.

The purpose of this run was to test the general procedure, such as thermocouple (TC) functioning, the ability to close the furnace door over TC leads, etc. One uncontaminated aluminum and one uncontaminated FRP ring were placed in the furnace for 10 minutes @ 900-1000°F. The TC of the aluminum ring performed as expected, that of the FRP ring fell off when the fiberglass part lost its integrity after the polyester binder burned off.

##### Run 2, Dry Run, 11 Feb 75.

This run, with uncontaminated samples, was used as the pattern for the following ones with agent. The bubblers were analyzed for background baseline data. The test rings were maintained in the furnace for 15 minutes at 1000°F. After cool-down and TC removal the rings were placed in 5 gal pails whose lids were taped shut. Airflow into the pails was from inside the capsule. Although no agent had contaminated the totally enclosed test area (capsule) at the time of this run, the bubblers of the incinerator measured 7.5 and 9.0 ng and those at the scrubber 18 and 19.5 ng GB per 15 ml of bubbler solution, which translates to air concentrations as follows:

Incinerator:  $1.48 \times 10^{-4}$  mg/m<sup>3</sup>

Incinerator:  $<1.23 \times 10^{-4}$  mg/m<sup>3</sup>

Scrubber:  $3.00 \times 10^{-4}$  mg/m<sup>3</sup>

Scrubber:  $3.25 \times 10^{-4}$  mg/m<sup>3</sup>

Right Ring:  $<1.25 \times 10^{-4}$  mg/m<sup>3</sup>



The average GB background level in the clean capsule is  $3.9 \times 10^{-4}$  mg/m<sup>3</sup> or almost four times the minimum detectable level. This is an appreciably larger discrepancy than found in later tests, for example run #5, where three samples had less GB than the minimum detectable but the fourth one had 20% GB over the minimum detectable.

Run 3, GB, 3 min nominal, 19 Feb 75.

This was the first test run with GB soaked rings. After incineration, the rings were removed from the furnace and TC wires pulled off, the rings and pails were taken to the shower entrance (Appendix II, Fig 1) to isolate them from the agent contaminated atmosphere. The rings were placed in the pails, and the lids closed and taped shut. The pails and bubblers were inside the capsule and the air drawn through pails and bubblers was from inside the capsule. Results show that many bubblers did not work, probably because of mechanical malfunctions, or had high levels of contamination. This could have originated from: 1) original undetoxified GB, 2) contamination of rings during TC removal, 3) infiltration of GB contaminated air into the pails, and 4) interference with the test itself by other chemicals such as TBA. Because the actual residence time in the furnace is about 5 1/2 minutes vs 3 minutes nominal, the binder of the FRP rings was almost totally consumed leaving nearly white fiberglass. This makes it more probable that the GB found in the bubblers did not originate with the rings but was introduced into the system later, such as during TC removal or from air infiltration into the pails.

Run 4, VX, 2 min, 20 Feb 75.

This test with VX was identical to the previous one with GB except for actual residence time. Two minutes in the furnace was clearly insufficient to incinerate all the binder of the fiberglass ring, yet all four bubblers of this test were below the detectable level.

Run 5, GB, 15 min nominal, 24 Feb 75.

The only procedural changes between this and previous runs was that the pail lids were crimped on rather than taped and that pails and bubblers were located outside of the capsule in the normal pilot plant atmosphere. All the organics were burned off the fiberglass and the aluminum rings were 70-90% coated with carbon black. Both bubblers of the left ring and one of the right ring were below the detectable limit of the test,  $<0.625 \times 10^{-4}$  mg/m<sup>3</sup>. The second right ring bubbler had a GB level barely above the detectable,  $0.75 \times 10^{-4}$  mg/m<sup>3</sup>. It is believed that this slight deviation reflects more on the accuracy of this test at the threshold limit of its sensitivity rather than indicates the presence of GB in the bubbler. This bubbler was only 20% above the lowest detectable level which is very little, compared to the background GB levels found during the dry run (run #1) before agents were introduced in this test series. At this time the average GB background level was four times the minimum detectable. The 20% discrepancies of this test is also much lower than



that found in one of two bubblers of a blank pail (166X) of run #8. Near the limit of detectability the laboratory reports much interference with the enzyme test, mostly from tributylamine (TBA). It is unfortunate that no sample has been retained for retesting. A second value of GB above the detectable would indicate that it and the original were probably caused by TBA or other contamination, since it could be assumed that any real traces of GB would have hydrolyzed out of the sample. Irrespective of the cause for the slight anomaly, this bubbler meets the stack emissions level with a safety factor of 4.

Run 6, VX, 15 min nominal, 25 Feb 75.

Conditions of this run parallel those of GB Run #5, all the binder was burned off the FRP tube. The VX level of both rings and of the control pail were  $<0.125 \times 10^{-4}$ , below the detectable VX level for this test, and 2.5 times lower than the VX stack standard. VX was detected in the capsule atmosphere, indicating that the test could detect VX.

Run 7, GB, 1 min nominal, 18 Mar 75.

The one minute residence time was much too short to burn off the polyester binder of the rocket tube, on removal from the oven they continued to burn actively for about 1/2 min. After the burning stopped the rings were put in their respective pails. The right pail and the blank control pail were below the detectable level for GB,  $<0.67 \times 10^{-4}$  mg GB/m<sup>3</sup> while the left pail had 2.5 and  $2.83 \times 10^{-4}$  mg GB/m<sup>3</sup> air. The one minute residence time is clearly insufficient to incinerate the binder of the rocket tubes. If any agent had penetrated within the fiberglass matrix there is no assurance that it would have been exposed to sufficient temperature to be detoxified.

Run 8, GB, 5 min nominal, 26 Mar 75.

At the start of this run the furnace flamed out, this resulted in a four minute delay during a preprogrammed purge cycle during which the temperature leveled off at 500°F for about 3 minutes before resuming its ascent to 1000°F. Both bubblers of the left pail were below the detectable level for this test  $<1.24 \times 10^{-4}$  mg/m<sup>3</sup>. While the right bubblers averaged  $5.17 \times 10^{-4}$  mg/m<sup>3</sup>. This represents a four fold average difference which is probably real. The discrepancy between the two bubblers of the blank pail is more questionable. While one was  $<1.24 \times 10^{-4}$  the other one was  $2.06 \times 10^{-4}$  mg/m<sup>3</sup>. This 70% increase over the minimum detectable level seriously challenges the reliability of the test since there should be no agent in the air sample of this blank pail, unless there was an unreported agent leak in the pilot plant ambient atmosphere. With these types and levels of discrepancies, the slight anomaly of run 5 becomes increasingly acceptable.











TEST RING SECTIONS IN PILOT INCINERATOR  
 VX Runs No ④ 20 Feb, No ⑥ 25 Feb 75

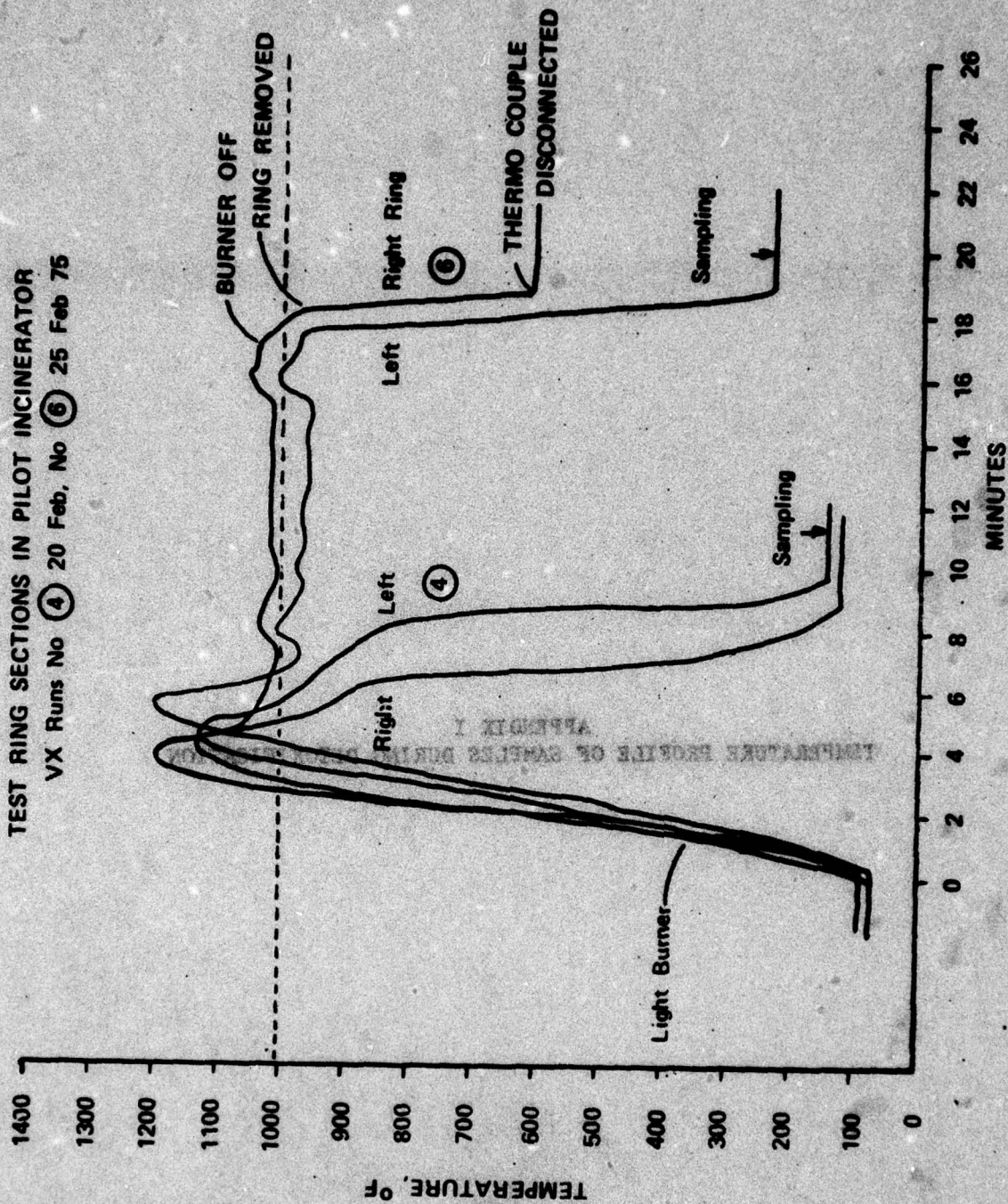


FIGURE 1 THERMAL DETOXIFICATION OF M55 ROCKETS



# TEST RING SECTIONS IN PILOT INCINERATOR

GB RUNS NO. ③ 19 Feb. NO. ⑤ 24 Feb 75

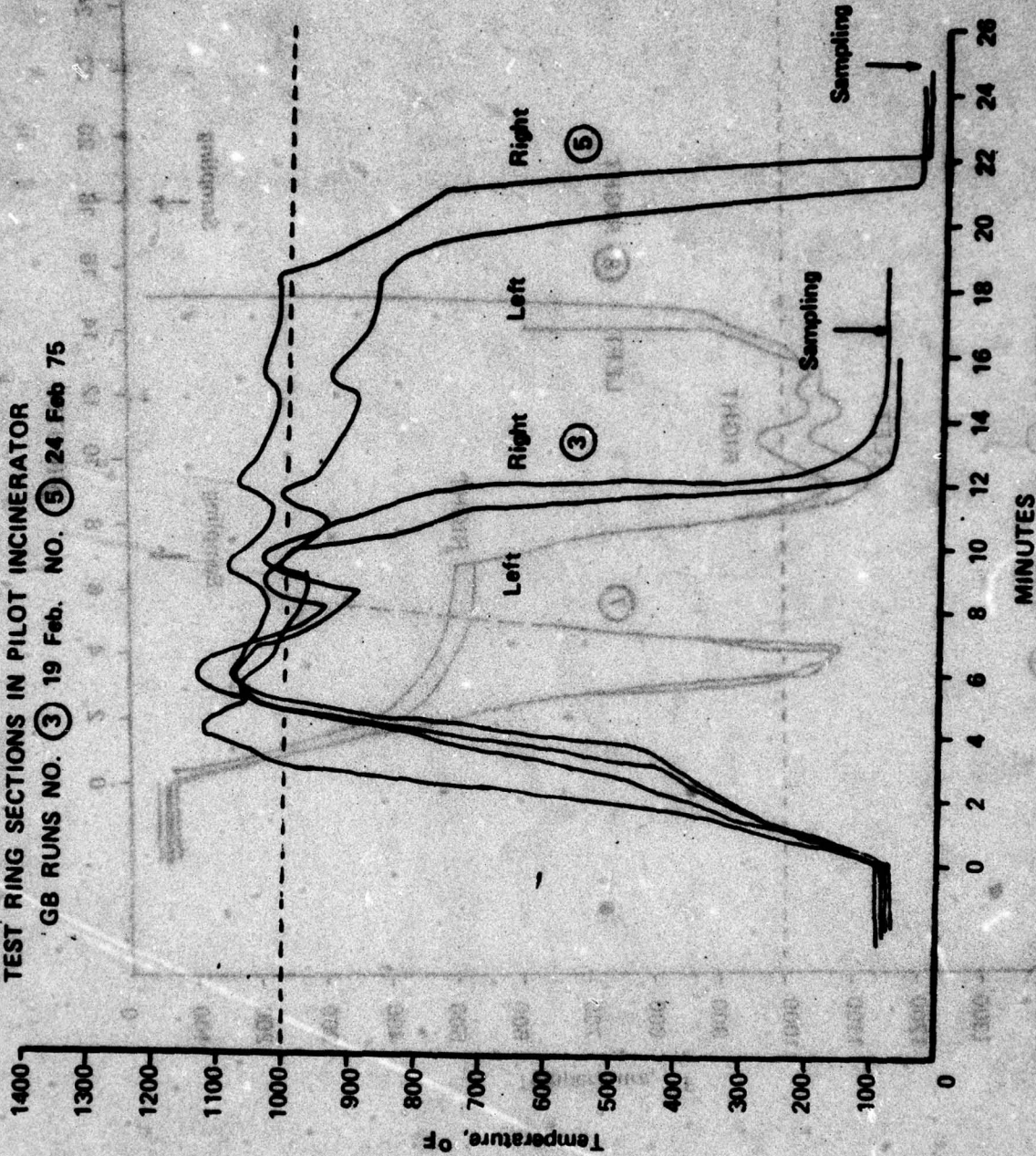


FIGURE 2 THERMAL DETOXIFICATION OF M55 ROCKETS



# FIGURE 3 TEST RING SECTIONS IN PILOT INCINERATOR

GB RUNS NO. ⑦ 19 Mar. NO. ⑧ 26 Mar.

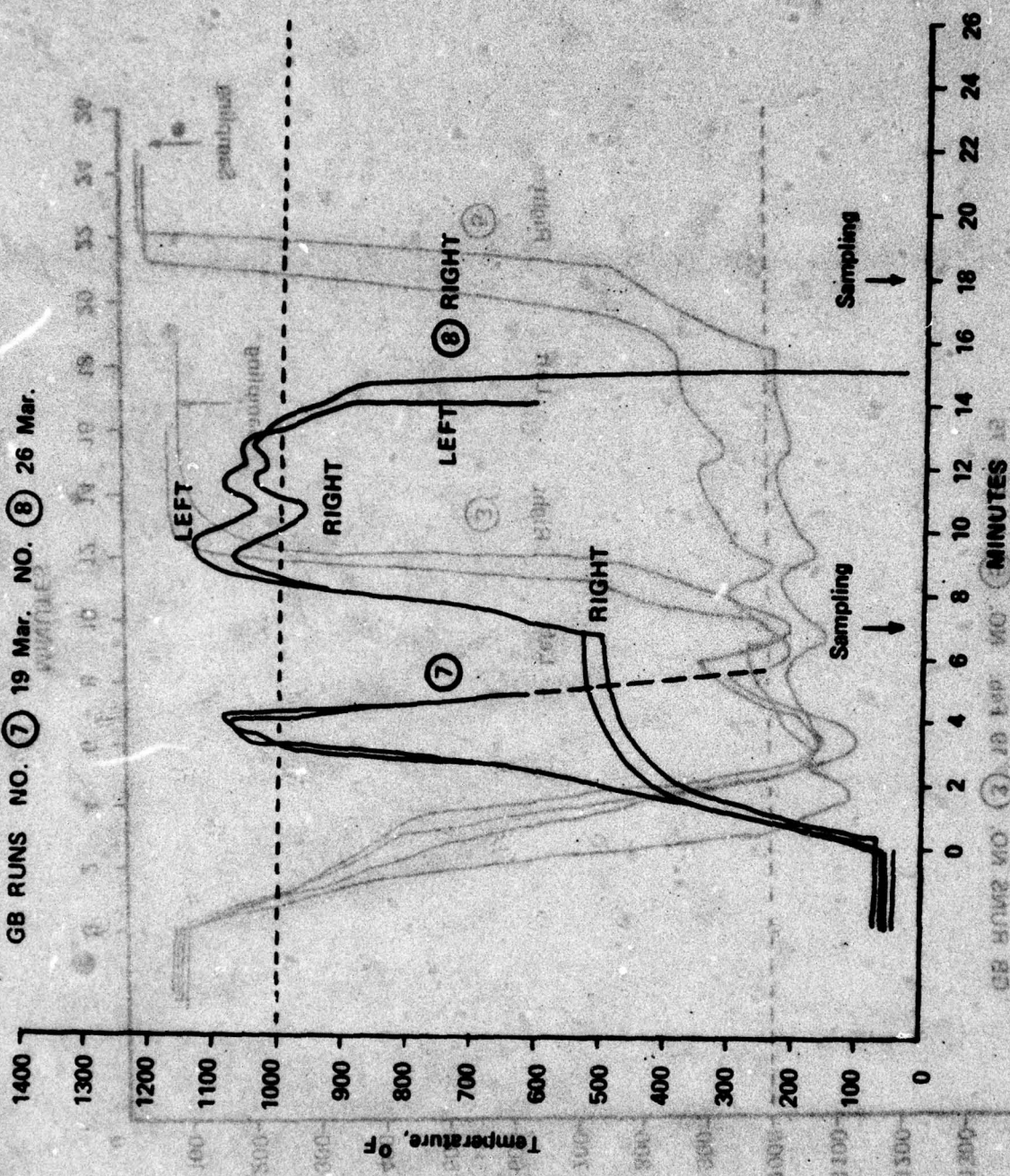
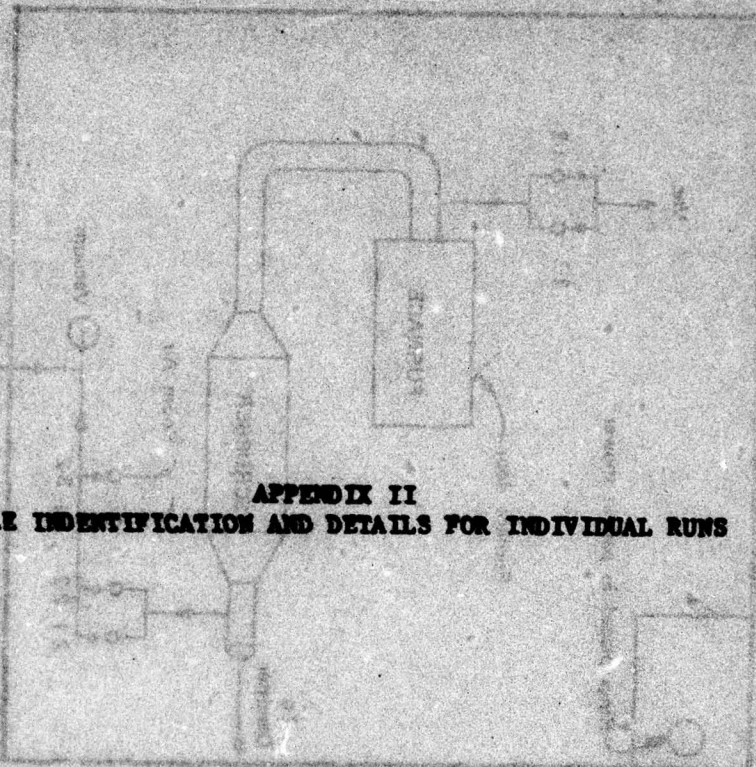
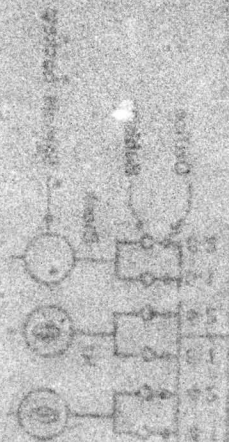


FIGURE 3 THERMAL DETOXIFICATION OF M55 ROCKETS



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SECTION 1 IDENTIFICATION OF WGS BOXES



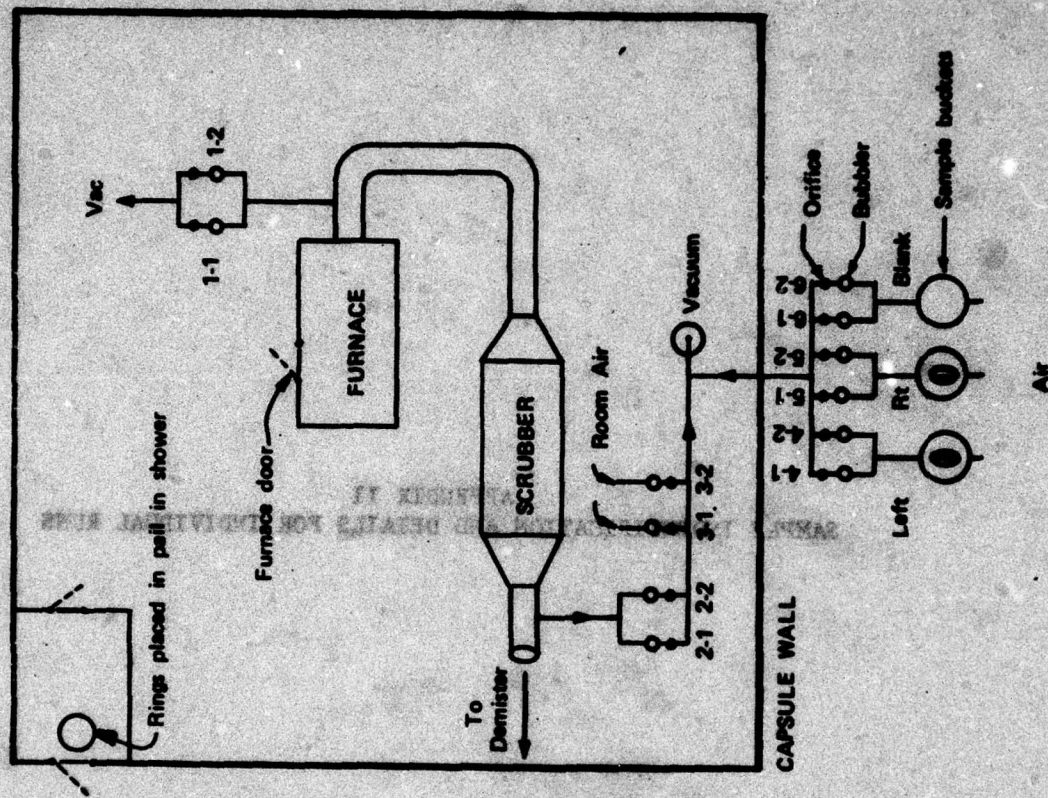
# APPENDIX II SAMPLE IDENTIFICATION AND DETAILS FOR INDIVIDUAL RUNS

SECTION 1 IDENTIFICATION OF WGS BOXES



**BUBBLER SETUP FOR RUNS:**

Run ⑤ 2 GB 15 min at 1000°F 24 Feb  
Run ⑥ 3 VX 15 min at 1000°F 25 Feb



**FIGURE 1 THERMAL DETOXIFICATION OF M55 ROCKETS**



# THERMAL DETOXIFICATION OF M55 ROCKETS

<u>RUN</u>	<u>DATE</u>	<u>OBJECTIVE</u>	<u>SAMPLING SETUP</u>
(1)	4 Feb 75	Preliminary test with no agent to check out thermocouples and procedure.	No sampling
(2)	11 Feb 75	No agent, background, data and procedure.	Background samples. Pail by incinerator
(3)	19 Feb 75	GB 1000°F/momentarily Test for detox	Taped pail lid. Pail inside capsule Air from outside
(4)	20 Feb 75	VX 1000°F/momentarily Test for detox	Taped pail lid. Pail inside capsule Air from outside
(5)	24 Feb 75	GB 1000°/15 min Test for detox	Crimped pail lid.* Pail outside capsule
(6)	25 Feb 75	VX 1000°/15 min Test for detox	Crimped pail lid. Pail outside capsule
(7)	19 Mar 75	GB 1000°F/momentarily Test for detox	Crimped pail lid. Pail outside capsule
(8)	26 Mar 75	GB 1000°F/5 min Test for detox	Crimped pail lid. Pail outside capsule

NOTE: Finalized procedure



**RUN (2) BUBBLER SCHEDULE, 11 Feb 75**  
**No agent**

<u>VAPORS</u> <u>SAMPLED</u>	<u>SAMPLE</u> <u>PERIOD</u>	<u>MINUTES</u>	<u>BUBBLER</u> <u>Nos.</u>	<u>NANOGRAM</u> <u>PER BUBBLER</u>	<u>γ/L</u>
Incinerator	1502-1603	61	(1-1)	9.0	$1.48 \times 10^{-4}$
			(1-2)	<7.5	$<1.23 \times 10^{-4}$
			(1-3 Spiked)	141	No change
			(1-4 Spiked)	141	No change
Scrubber	1503-1603	60	(2-1)	18	$3.0 \times 10^{-4}$
			(2-2)	19.5	$3.25 \times 10^{-4}$
			(2-3 Spiked)	138	No change
			(2-4 Spiked)	140	No change
Left Ring Bucket	1502-1603	61	(3-1 Spiked)	141	No change
			(3-2 Spiked)	141	No change
Right Ring Bucket	1502-1603	61	(4-1)	<7.5	$<1.23 \times 10^{-4}$
			(4-2 Spiked)	141	No change

All spiked samples were 142 nanogram GB/bubbler. Taped bucket lids, inside capsule, air from inside.



**RUN (3) BUBBLER SCHEDULE, 19 Feb 75**  
**GB 3 min at 1000°f**

<u>VAPORS SAMPLED</u>	<u>SAMPLE PERIOD</u>	<u>MINUTE</u>	<u>BUBBLER Nos.</u>	<u>NANOGRAM PER BUBBLER</u>	<u>Y/L</u>
Incinerator Blank	1235-1335	60	(1-1		
			(1-2		
			(1-3 Spiked	Didn't work	
			(1-4 Spiked		
Scrubber	1235-1335	60	(2-1		
			(2-2		
			(2-3 Spiked	Didn't work	
			(2-4 Spiked		
Incinerator	1430-1641	131	(1-1	7.5	$0.572 \times 10^{-4}$
			(1-2	135	$10.3 \times 10^{-4}$
Scrubber	1430-1641	131	(2-1	1440	$110 \times 10^{-4}$
			(2-2	1590	$121 \times 10^{-4}$
Left Ring Bucket	1441-1641	120	(3-1	3360	$280 \times 10^{-4}$
			(3-2	Didn't work	
Right Ring Bucket	1441-1641	120	(4-1	Didn't work	
			(4-2	2335	$236 \times 10^{-4}$

Taped bucket lid, inside capsule, air from outside.

Run (4) BUBBLER SCHEDULE, 20 Feb 75

VX 2 min at 1000°F

Vapors Sampled	Sample Period	Minutes	Bubbler Nos.	Nanogram per bubbler	VX
Incinerator	1318-1525	127	(1-1)	4.0	$0.315 \times 10^{-4}$
			(1-2)	3.2	$0.252 \times 10^{-4}$
Scrubber	1318-1525	127	(2-1)	< 1.5*	$< 0.118 \times 10^{-4}$
			(2-2)	< 1.5	$< 0.118 \times 10^{-4}$
Left Ring Bucket	1325-1525	120	(3-1)	< 1.5	$< 0.125 \times 10^{-4}$
			(3-2)	< 1.5	$< 0.125 \times 10^{-4}$
Right Ring Bucket	1325-1525	120	(4-1)	< 1.5	$< 0.125 \times 10^{-4}$
			(4-2)	< 1.5	$< 0.125 \times 10^{-4}$

Taped bucket lid, inside capsule, air from outside. \*1.5 ng VX/bubbler is limit of analytical sensitivity.



Run (5) BUBBLER SCHEDULE, 24 Feb 75

F. GB 15 min at 1000°F

Vapors Sampled	Sample Period	Minutes	Bubbler Nos.	Nanogram per bubbler	$\gamma$
Incinerator	1306-1529	143	(1-1)	111	$7.77 \times 10^{-4}$
			(1-2)	74	$5.17 \times 10^{-4}$
Scrubber	1306-1529	143	(2-1)	342	$23.9 \times 10^{-4}$
			(2-2)	291	$20.3 \times 10^{-4}$
Air Inside Capsule	1329-1529	120	(3-1)	98	$8.17 \times 10^{-4}$
			(3-2)	130	$10.8 \times 10^{-4}$
Left Ring In Bucket Outside Capsule	1329-1529	120	(4-1)	< 7.5*	< $0.625 \times 10^{-4}$
			(4-2)	< 7.5	< $0.625 \times 10^{-4}$
Right Rings In Bucket Outside Capsule	1329-1529	120	(5-1)	< 7.5	< $0.625 \times 10^{-4}$
			(5-2)	~ 9	$0.75 \times 10^{-4}$
Blank Bucket Outside Capsule	1329-1529	120	(6-1)	< .75	< $0.625 \times 10^{-4}$
			(6-2)	< .75	< $0.625 \times 10^{-4}$

\* 7.5 ng GB/Bubbler is limit of analytical sensitivity



Run (6) BUBBLER SCHEDULE, 25 Feb 75

VX 15 min at 1000°F

Vapors Sampled	Sample Period	Minutes	Bubbler Nos.	Nanogram per bubbler	$\mu\text{g}$
Incinerator	1251-1510	139	(1-1)	42	$3.02 \times 10^{-4}$
			(1-2)	48	$3.45 \times 10^{-4}$
Scrubber	1251-1510	139	(2-1)	288	$20.7 \times 10^{-4}$
			(2-2)	315	$22.6 \times 10^{-4}$
Air Inside Capsule	1310-1510	120	(3-1)	6.9	$0.575 \times 10^{-4}$
			(3-2)	8.7	$0.725 \times 10^{-4}$
Left Rings in bucket outside capsule	1310-1510	120	(4-1)	< 1.5	< $0.125 \times 10^{-4}$
			(4-2)	< 1.5	< $0.125 \times 10^{-4}$
Right Rings in bucket outside capsule	1310-1510	120	(5-1)	< 1.5	< $0.125 \times 10^{-4}$
			(5-2)	< 1.5	< $0.125 \times 10^{-4}$
Blank Bucket outside capsule	1310-1510	120	(6-1)	< 1.5	< $0.125 \times 10^{-4}$
			(6-2)	< 1.5	< $0.125 \times 10^{-4}$

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Run (7) BUBBLER SCHEDULE, 19 Mar 75

GB 1 min at 1000°F

<u>Vapors Sampled</u>	<u>Sample Period</u>	<u>Minutes</u>	<u>Bubbler Nos.</u>	<u>Nanogram per bubbler</u>	<u>Ky/L</u>
Incinerator	1322-1526	124	(1-1)	23,600	$1900 \times 10^{-4}$
			(1-2)	15,800	$1273 \times 10^{-4}$
Air Beside Incinerator	1322-1526	124	(2-1)	2570	$207 \times 10^{-4}$
			(2-2)	1480	$119 \times 10^{-4}$
Scrubber	1322-1526	124	(3-1)	297	$23.9 \times 10^{-4}$
			(3-2)	206	$16.6 \times 10^{-4}$
Air Beside Scrubber	1322-1526	124	(4-1)	536	$43.2 \times 10^{-4}$
			(4-2)	528	$42.5 \times 10^{-4}$
Left Ring In Bucket Outside Capsule	1326-1526	120	(5-1)	30	$2.50 \times 10^{-4}$
			(5-2)	34	$2.83 \times 10^{-4}$
Right Ring In Bucket Outside Capsule	1326-1526	120	(6-1)	< 8	$< 0.67 \times 10^{-4}$
			(6-2)	< 8	$< 0.67 \times 10^{-4}$
Blank Bucket Outside Capsule	1326-1526	120	(7-1)	< 8	$< 0.67 \times 10^{-4}$
			(7-2)	< 8	$< 0.67 \times 10^{-4}$

843



Run (8) BUBBLER SCHEDULE, 26 Mar 75

GB 5 min at 1000°F

Vapors Sampled	Sample Period	Minutes	Bubbler Nos.	Nanogram per bubbler	$\gamma/\lambda$
Incinerator	1040-1257	137	(1-1)	81,900	$5970 \times 10^{-4}$
			(1-2)	76,200	$5560 \times 10^{-4}$
Scrubber	1040-1257	137	(2-1)	1620	$118 \times 10^{-4}$
			(2-2)	1200	$87.5 \times 10^{-4}$
Left Ring In Bucket Outside Capsule	1056-1257	121	(3-1)	< 15	$< 1.24 \times 10^{-4}$
			(3-2)	< 15	$< 1.24 \times 10^{-4}$
Right Ring In Bucket Outside Capsule	1056-1257	121	(4-1)	86	$7.11 \times 10^{-4}$
			(4-2)	39	$3.22 \times 10^{-4}$
Blank Bucket Outside Capsule	1056-1257	121	(5-1)	< 15	$< 1.24 \times 10^{-4}$
			(5-2)	25	$2.06 \times 10^{-4}$



# APPENDIX III PILOT PLANT SUMMARY OF INDIVIDUAL RUNS

Run (7) G2, (8) V2, (9) V2 at 1000°F

Physical properties for each agent are as follows: 1000°F for 15 min indicated agent vapor levels below detectable amounts in all samples except for one. Gas analysis (2-3 of 5) showed 0.1%  $\text{CO}_2$  and 0.1%  $\text{CO}$  of vapor, slightly above the 0.05%  $\text{CO}_2$  and 0.05%  $\text{CO}$  analytical sensitivity. For these two runs, gas analysis was not made. The toxic analysis was also indicating the possibility of a leak of toxic vapors from the apparatus. See V2, I, Appendix II. Actual temperature varied from 1000°F during the 15 min as shown on the temperature graph, Appendix I.

Run (8) V2, (9) V2 at 1000°F

Results for this run also indicated below detectable amounts of agent vapor from the sample pan. The fact that the sample pan and sublimator for this run were located inside the capsule did not adversely affect the results. I.e., obviously no vapors from capsule leaked in the pan.

Temperature peaked at 1150°F left box, 1190°F right ring as shown by the plot.

Run (9) G2, (10) V2 at 1000°F

Gas analysis showed high amounts of  $\text{CO}_2$  in the vapors, 1.5%  $\text{CO}_2$  and 1.5%  $\text{CO}$ . The temperature graph, too, indicated about four minutes spent

## APPENDIX III PILOT PLANT SUMMARY OF INDIVIDUAL RUNS

The possibility of leakage of toxic vapors into the sample pan or flask from the run cannot be ruled out (although no specific evidence of leakage was observed).

Distillation of rings during the removal of thermocouple wires and other handling prior to placing in the bucket was a possibility. The rings were being worked out.

There appeared to be no clear correlation between the agent concentration in vapors from the rings and the appearance of the rings, i.e., carbon coating and other glass color and inclusions. The rings of run 3 had heavy glass more loose and bluish than others and carbon coating was evident.

The carbon black coating may be from the burned plastic.



APPENDIX III  
PILOT PLANT SUMMARY OF INDIVIDUAL RUN

Run (5) GB, (6) VX 15 minutes at 1000°F:

Analytical results for both agent runs at 1000°F for 15 min indicated agent vapor levels below detectable amounts in all samples except for one. One bubbler (5-2 of Run 5) showed  $0.75 \times 10^{-4}$   $\gamma$  GB/l of vapor, slightly above the  $0.625 \times 10^{-4}$  analytical sensitivity. For these two runs, pails and bubblers were kept outside the toxic capsule thus eliminating the possible pick up of toxic vapors from the surroundings. See Fig 1, appendix II. Actual temperature varied some from the 1000°F during the 15 min as shown on the temperature profiles, appendix I.

Run (4) VX 2 minutes at 1000°F:

Results for this run also indicated below detectable amounts of agent vapors from the sample pails. The fact that the sample pail and bubblers for this run were located inside the capsule did not adversely affect the results, i.e., obviously no vapors from capsule leaked in the pails.

Temperatures peaked at 1130°F left ring, 1190° right ring as shown by the plot.

Run (3) GB 3 minutes at 1000°F:

Results showed high amounts of GB in the vapors,  $258 \times 10^{-4}$   $\gamma$ /l from the temperature profile, two peaks were attained about four minutes apart at 1030° and 1070°F.

The possibility of leakage of toxic vapors into the sample pail or lines from the room cannot be ruled out (although no specific evidence of leakage was observed).

Contamination of rings during the removal of thermocouple wires and other handling prior to placing in the bucket was a possibility. Technique was being worked out.

There appeared to be no clear correlation between the agent concentration in vapors from the rings and the appearance of the rings, i.e., carbon coating and fiber glass color and looseness. The rings of run 3 had fiber glass more loose and binder free than others and carbon coating was moderate.

The carbon black coatings may be from the burned plastic.



Runs (7) and (8) were an attempt to get GB detoxification at the shorter burn times (1 and 5 min) using best handling and sampling procedures. Run (7) represented the shortest time at 1000°F (about 1 min) and the shortest total time in the furnace (about 6 min). The plastic was still burning when removed from the furnace. One of the rings showed no measurable toxicity; the other indicated toxicity approx twice the analytical sensitivity,  $2.7 \times 10^{-4}$  y/l.

Run (8) GB 5 min @ 1000°F:

GB conc, as high as  $7.1 \times 10^{-4}$  y/l was reported for one ring; the other ring had no measurable amount. The fact that the blank sample coil showed some toxicity (although slight) may indicate that toxicity was picked up from outside the sample vessels during this series.

The flame out and delay in temperature is not believed to have appreciably affected the results. If it was a factor, it would have aided the detoxification since this would have been heat in addition to the 5 min period above 1000°F.



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The time out was delay in response is not believed to have appreciably affected the results. It was a factor, it would have added the delay location since this would have been near in addition to the 5 min period above 1000 ft.



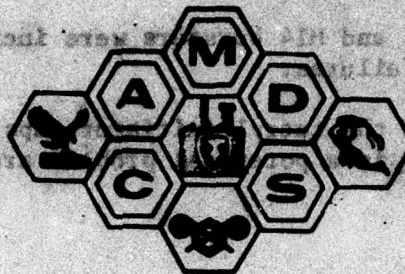
PRELIMINARY TEST REPORT

FOR

ED #3/74 DEACTIVATION FURNACE/SCRUBBER (DFS)

Thermal Deactivation of  
Explosive Components of  
Chemical Munitions (4.2" Mortar)  
Test No. CAMDS 03-6A

20 Mar 1975



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Chemical Agent Munition Disposal System  
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file 6/5/75  
pc

REF ID: A60151-27 REPORT



## ABSTRACT

### 1. Background.

It was required to verify that the high explosive (HE) components of the 4.2" mortar could be safely deactivated thermally at the proposed configuration and feed rates. The remainder of the HE components of the chemical munitions will be tested as they are made available. The thermal deactivation test of the mortar components (M8 fuses and M14 bursters) was conducted at the CAMDS test site, Tobolsk South Area, with the APE 1236 furnace on 6 Mar 1975.

### 2. Summary of results and conclusions.

a. Two hundred M8 fuses and M14 bursters were incinerated without adverse incident or system failures.

b. Approximately 28% of the tetryl initiator cups fell out of the fuses during handling. This is a potential problem area in a future automated system.

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Chemical Agent Neutralization System  
Small Munition Section  
Edgewood Arsenal  
Aberdeen Proving Ground, MD 21010



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Appendix A - Furnace Operating Log

Appendix B - Scrubber Operating Log



## **I. PURPOSE.**

The purpose of this test is to verify that the proposed configuration of the explosive components of the 4.2" mortar munition can be safely deactivated in the Deactivation Furnace at the design feed rate to satisfy the anticipated CAMDS production rate. The test requirements are specified in Test Plan No. CAMDS 03-6, Thermal Deactivation of Explosive Components of Chemical Munitions, dated 5 Feb 75.

## **II. OBJECTIVES.**

- A. Verify that proposed configuration of the M14 burster and the M3 fuse from the 4.2" mortar munition can be safely deactivated in the CAMDS deactivation furnace without high order explosions.
- B. Verify feed rate and configuration for the 4.2" mortar munition.
- C. Determine optimum feed sequence.
- D. Process 200 fuses and bursters combination without incident.



### III. TEST ACCOMPLISHMENTS.

The furnace was operated for two hours in order to attain a "practical" thermal equilibrium. The first fuse was put on the inlet conveyor with the furnace feed end temperature at 640-660°F. Nominal retention times of the retort and of the conveyors are 8 minutes and 1 minute each respectively. After 10 minutes the first burster was placed on the inlet conveyor. No report was heard during the incineration of either the M8 fuse or of the M14 burster. The feed rate of successive items was doubled until the 5th and 6th fuse and bursters were fed at the normal rate of one set per minute. The actual feed sequence was two fuzes together, followed by two bursters, also in pairs.

When the 31st (or 32nd) burster was fed there was a very mild deflagration. It did not produce either physical damage or overpressurization (puffing) of the furnace. The burster tubes that exited the furnace 10 minutes after this occurrence showed no blast effect. Because of the mildness of the report, feed was not interrupted. This was the only incident noted during the entire run.

After approximately 1-1/2 hours of operation it was decided to separate the items produced during the first half of the burn (placed in Drum #1) from those of the last half (Drum #2) and compare them for temperature effects, if any. Throughout the run temperature increased slightly with time. Some changes that were noticed that were probably temperature induced were: a) some of the closed ends of the burster tubes came off, b) the point, or top of some of the fuzes were broken off, c) some fuzes were split in half longitudinally. These various items were counted and their frequency of occurrences are listed below:

	<u>Drum #1</u> <u>(cooler)</u>	<u>Drum #2</u> <u>(hotter)</u>
burster tubes - undamaged	61%	47%
burster tubes - w/o end	39%	53%
fuzes - whole (undamaged)	95%	18%
fuzes - partial (w/o top)	5%	72%
fuzes - split in half	-	6%
fuzes - melted	-	4%*

NOTE: Five missing fuzes were assumed to account for the aluminum totally melted or for pieces too small to be identifiable.

The actual temperature differences cannot be accurately determined. For example, the burner temperature reflects more than anything else the



fact that the auxilliary blower is either on or off. Even if the effect is minimized, as when the blower is off (as in this test), a variation of 240°F can be seen (Appendix A). One factor affecting this temperature is a very small change of the oil/air ratio, as could be caused by vibrations during operation on manual control. Air infiltration affects the readings on the burner and thermocouple as well as those of the stack thermocouple (the one controlling the furnace during automatic operation). At present the best indication of the heat level of any operation is a record of surface temperature changes. The data of this burn show that the furnace temperature during the second half of the test burn was definitely higher. The quality of the data reflect the fact that these were taken with a combination of one radiation pyrometer and two contact thermometers. This should improve radically for future burns when the three IR radiation pyrometers are put in service.

During the handling of the fuzes it was observed that the relay charge, holding a 2 grain tetryl pellet, and situated at the base of the fuze can fall free. During this run, the pellets actually collected at the bottom of the packing cases, and it could be surmised, would collect at various low points of an automated handling system. In this burn 27% of the relay charges had fallen free of the fuzes. Although this projects to a total accumulation of 0.10 pounds in a week of operation it represents a potential problem area to be addressed in the future.

The potential for jam-ups caused by the 14" burster tubes must be considered. For example, although the tubes normally exit the outlet conveyor laying flat horizontally, one was observed leaving the outlet conveyor erect (vertical). In this position it pushed the outlet damper completely open but fell free before causing a conveyor jam. Another tube was found considerably bent (1-1/2" bow in 14"L; ~12° angle). This must be the result of having hung up somewhere in the system. In this case there was no jam-up since the stress was relieved by the bowing of the tube. Nevertheless, it is felt that statistically more severe jam-ups should be anticipated. This is being addressed by the contractor.

Another potential problem area to be addressed is the eventual disposition of molten aluminum. Even if the furnace operating conditions result in a thermal profile below the melting point of aluminum it must be assumed that temperature transients will exceed this point, for example where the explosive components burn. When the system is operated for extended periods this will result in accumulations of molten aluminum that could have damaging effects if allowed to solidify. This shows up now with outlet conveyor jams when, after extended down periods between tests, it is necessary to chip away solidified aluminum before the conveyor can be restarted. The aluminum problem is being addressed by the contractor (Midland-Ross) designing the retort for the CAMDS.



#### IV. CONCLUSIONS.

- A. The M8 fuze and M14 bursters can be thermally deactivated in the present test deactivation furnace.
- B. An absolute rate of one set per minute at the actual sequence of two fuzes added together followed by bursters also added in pairs is satisfactory.
- C. A feed temperature at the furnace inlet in the range of  $700 \pm 50^{\circ}\text{F}$  is acceptable.
- D. Only one, very mild deflagration was heard during the incineration of 200 sets of fuze and bursters.
- E. Two burster tubes caused temporary hangups in the system, but not sufficiently severe to cause stoppages.

#### V. RECOMMENDATION.

It is recommended that considerations be given to the potential problems resulting from the fact that the tetryl initiators fall out of the fuzes during handling.

#### VII. DISTRIBUTION.

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1

11/2/20

Standard 11-14 and 20.

15008 6744 FIELDWORK DATA



1-60

DATE: 6 March 75  
Sheet 1 of 1

M-8 Fuses, M-14 Burstlers

DEAC SCRUBBER DATA SHEET

TIME		0945	1045	1230
RECYCLE LIQUID				
1. TEMP TO SCRUBBER	°F	62	62	62
2. TEMP FM CLONES	°F	72	76	76
3. FLOWS				
A. TO VENTURI	GPM	9	9	9
B. TO BED SEC 1	GPM	5	5	5
C. TO BED SEC 2	GPM	0	0	0
FAN INLET PRESSURE		14.6	14.5	14.7
SCRUBBER ΔP		14.6	-	-
VENTURI EXIT TEMP 1	°F	92	92	94
VENTURI EXIT TEMP 2	°F	100	101	105
GAS TEMP-SCRUBBER EXIT	°C	90	90	94
SCRUBBER LEVEL		110/115	63.5	65
POLYCLONE PRESSURE		24.6	69/13	60/13
WATER TO QUENCH		GPM	9	9
WATER TO CYCLONE QUENCH			-	-
CYCLONE TEMP			-	-
WEB SPRAY PRESSURE				
WEB ΔP		14.6	7.5	7.5

A.

B.

C.

D.

E.

F.

G.

H.

I.

J.



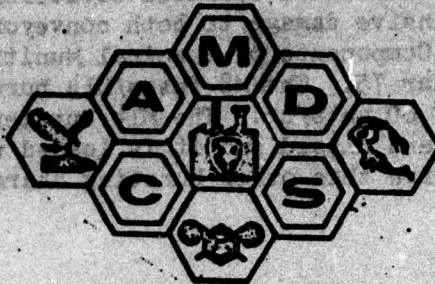
TEST REPORT

FOR

EW3-4 - DEACTIVATION FURNACE SYSTEM (DFS)  
THERMAL DEACTIVATION OF EXPLOSIVE  
COMPONENTS OF CHEMICAL MUNITIONS  
(PROJECTILES FUSES AND BURGERS)

TEST NO. CAMDS 03-63

17 JUN 73



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## ABSTRACT

1. Background. Verification that the high explosive (HE) components of the chemical munitions could be safely deactivated thermally at the proposed CAMDS configurations and feed rates was required. The thermal deactivation tests were carried out at the CAMDS test site, Tooele South Area, with the AFE 1236 furnace between 29 May and 9 Jun 75, according to Test Plan CAMDS 03-6 with Addendum #1.

2. Previous Reports. "Thermal Destruction of M23 Landmines" Test No. CAMDS 03-2, 18 Dec 74. M23 landmines can be thermally deactivated at the rate of 40/hr providing that the M120 boosters are separated from M38 bursters. Attempts to incinerate unseparated boosters/bursters resulted in explosions causing extensive damage to both conveyor systems. "Thermal Deactivation of Explosive Components of Chemical Munitions (4.2" Mortar)" Test No. CAMDS 03-6A, 20 Mar 75. The M8 fuses/M14 bursters were thermally deactivated at the rate of 60 sets/hr. The M14 burster challenged the system because it has one end closed and it is loaded with tetryl which is appreciably more sensitive than other bursting charges.

### 3. Summary of Results.

a. HE components were incinerated as follows:

200 M71 @ 30/hour and 40 @ 40/hr  
200 M557-M40A1 @ 30/hour and 40 @ 40/hr  
200 M557 - M5 @ 30/hour and 40 @ 40/hr  
200 M83 @ 24/hour

b. There was no pressure excursion of any consequence during the whole test series but the bursters with steel cases such as the M40A1 and M5's caused many outlet conveyor jam-ups, the majority of which were cleared with the reverse jog mechanism. Similar stoppages were caused by the short aluminum section of the M83 bursters.



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VII. DISTRIBUTION	

1. Verify that the configuration of the emissions will be compatible with proper furnace operation.

2. To test feasibility of CAMDS production and design team input.

3. To process 200 of each available feed at the CAMDS feed rate and 20 at the slightly higher "design" feed rates.

4. To optimize the feed sequence.

## III. TEST ACCOMPLISHMENTS

1. UNIT 1 - 4000 LBS - 4000 LBS. The WYI burner is used in the initial portion of the 1000 hour test. It is rated at 1.5 x 10<sup>6</sup> Btu/hr. The design is an aluminum case 14 1/2" x 2" x 1 1/2" ID. The distribution of the burner is 10-11 from the burner and section in two parts. The burner is adjacent to the case in one to a length of 14 1/2" and holds the line of flow. The small piece is 1 1/2" long, has one end closed, and holds 0.15 lbs of explosive. The situation of the burner case is extended to weigh 1.1 lbs.

The large burner section was fed to the burner line and did not produce any visible report. The case acted approximately 10 minutes later showing only effects of controlled burning. The small section was added and there was no sign of accelerated combustion. The line between addition of successive burner sections was delayed until the desired feed rate of one burner every two minutes was attained. The furnace was operated at a high burner setting of 0.15 (all in air test) at about 850 gph. This gave furnace with temperature near the end of the test as follows:

EXHIBIT 100

EXHIBIT 100

EXHIBIT 100

9557

9557

9557



## I. PURPOSE

The purpose of this test is to verify that the proposed configurations of the explosive components of the 105mm, 155mm, and 8 inch howitzer projectile can be safely deactivated in the Deactivation Furnace System (DFS) at both the design feed rate and the anticipated CAMDS production rate. The test requirements are specified in Test Plan No. CAMDS 03-6, "Thermal Deactivation of Explosive Components of Chemical Munition", dated 5 Feb 75 and amended by Addendum #1, dated 22 May 75.

## II. OBJECTIVES

- A. Verify that the proposed configuration for the M71 burster, the M557 Fuse - M40A1 burster, M557-M5 bursters, and M83 bursters can be safely deactivated in the CAMDS furnace without damaging high order pressure excursions.
- B. Verify that the configuration of the munitions will be compatible with proper furnace operation.
- C. To test feasibility of CAMDS production and design feed rates.
- D. To process 200 of each available item at the CAMDS feed rate and 40 at the slightly higher "design" feed rates.
- E. To optimize the feed sequence.

## III. TEST ACCOMPLISHMENTS

A. Run 1 - 29 May 75 - M71 Bursters. The M71 burster is used in the M121A1 projectile of the 155mm howitzer. It contains 2.45 lbs of Comp B in an aluminum tube 17 1/4" L x 2" OD and 1 3/4" ID. The deactivation furnace receives the M-71 from the burster saw station in two pieces. The large piece adjacent to the fuse is cut to a length of 14 3/4" and holds 2.09 lbs of Comp B; the small piece is 2 1/2" long, has one end closed, and holds 0.16 lbs of explosive. The aluminum of the burster case is estimated to weigh 1.1 lbs.

The large burster section was fed to the furnace first and did not produce any audible report. The case exited approximately 10 minutes later showing only effects of controlled burning. The small section was added and since there was no sign of uncontrolled combustion the time lag between addition of successive burster sections was halved until the desired feed rate of one burster every two minutes was attained. The furnace was operated at a high burner setting of 9/10 (oil to air ratio) or about 23.2 gph. This gave furnace skin temperatures near the end of the run as follows:

STACK END

825°F

CENTER

955°F

BURNER END

925°F



Early in the run the auxilliary blower was cut off to ascertain that the burner temperature was at least 500°F as specified in the SOP. With the recorder indicating 650°F and still climbing slowly, the blower was turned back on thus cooling the burner thermocouple to 400°F. The stack end temperature, near the feed section, was observed to be drifting slowly from 1400 to 1600°F and back during the run. With no logical cause for this slow drift it was thought that the furnace was reacting to changes in furnace draft resulting from variations in wind direction. This "last resort" theory had been proposed often in the past when no other logical one seemed to apply. The real cause for this thermocouple drift was later found to be due to a high resistance short between one of the thermocouple terminal and ground. Replacing the thermocouple corrected the "drift" problem (compare runs 3 and 4).

After the furnace was operating for about three hours it was noticed that the outlet conveyor had stopped discharging aluminum scrap. Since the furnace was not leaking between the flanges it was assumed that the aluminum was being retained by the furnace. After the burner was shut off, at the end of the run, aluminum scrap started to come out. It was in the form of broken "crumb" with some larger lumps. Most of this material had been partially or totally melted.

After the run, inspection of the feed conveyor showed that one of the 2 1/2" long piece of burster had hung up near the feed damper. It didn't seem damaged or affected by heat and was saved for recycling in a successive run. The inspection door at the feed end of the furnace was opened to ascertain that no other explosive loaded part had failed to fall into the retort. About three cubic feet of fiberglass and three M17 fuses of the M55 rocket were found in this area. The feed chute was also found damaged. Removing it for repair exposed the feed end of the furnace for inspection. The first two sections were entered, inspected and photographed. Although some aluminum was caught in the seam between the first and the second sections, the inside surface was relatively free of adhering metal or other material, or of deep pits, or other surface faults. The feed chute was repaired and the inspection door closed.

The furnace was started without lighting the burner and large pieces of aluminum dropped out. The aluminum lumps ranged from 10 to 20 lbs and the curvature of their outside surface was a good visual match for the curvature of the inside of the retort. Since these lumps were not seen when the inside of the furnace was inspected they probably were in the 3rd or 4th section, at the burner end of the retort. This indicates that the probable melting mechanism was controlled more by burner heat than Comp B combustion.

B. Run 2 - 2 Jun 75 - M557 Fuses-M40A1 Burster. The M40A1 is one of the bursters of the 105mm M360 Howitzer projectile whose agent fill is GB. The M-508 fuse is normally used with this round but was not available for this test. Instead the M557 fuse was substituted for the M508 since the fuses only differ by the delay train. The fuse contains 82 mg of tetryl and 218 mg of lead azide while the M40A1 holds 1.1 lbs of Comp B. The 12 1/2" burster has a 1.5" OD and a 1.4" ID. It is cut into two pieces, the large one is 10 1/2" long and holds 0.92 lbs Comp B, the small one is



2" long and has 0.18 lbs Comp B. The uncut end is closed off by an existing rubber plug. The M557 fuse has a very thin slice (1/8") cut off at the base of the M125 booster cup.

After a slow work up, the bursters and fuses were fed at the rate of 30/hr. During the incineration of 120 bursters the outlet conveyor jammed 10 times and required manual clearing once. The aluminum point (nose) of nine fuses (7.5%) was unmelted. They were recycled through the furnace only as a precaution.

C. Run 3 - 3 Jun 75 - M557 Fuses and M40A1 Bursters. The remaining 80 M40A1's were burned to make up the required 200 at 30/hr, then 40 more were incinerated at the increased rate of 40/hr. There was one outlet conveyor jam but it was cleared with the reverse jog mechanism.

D. Run 4 - 4 Jun 75 - M557 Fuses - M5 Bursters. With the furnace cold the stack end thermocouple was reading 1000°F. Changing the thermocouple solved the problem. It was found that two M557 fuses were not cut but were badly damaged by the saw, they were set aside and later returned to the igloo. The M5 burster is used in conjunction with the M557 fuse of the M60, 105mm Howitzer projectile filled with agent HD. The M5 is 12 1/2" long x 3/4" OD and holds 0.26 lbs of 70/30 tetrytol. It is cut into two pieces, 10 1/2" and 2" long holding 0.22 and 0.04 lbs of tetrytol respectively. These values apply to the steel cased burster. Some bursters had aluminum tubes with the same outside dimensions but smaller inside diameter and had an explosive fill which calculates to be only 2/3 of the steel bursters. The steel tubes have a clear varnish covering and bear no lot number. The aluminum ones had lot number 8-8865-27-COD Apr 62.

As in prior runs, lumps of aluminum that had collected the previous day, discharged at the start of the run. Similarly, when the furnace became hot it started to retain the aluminum of the burster tubes. The furnace was operated hot, at a Hauck valve setting of 10/10 for the first half of the run and 8/10 (oil/air) for the second half of the run. These represent approximate oil rates of 25 gph and 21.5 gph. These rates gave typical temperatures as follows:

	STACK	BURNER
Internal temperature, °F	800°	800°
Skin temperature, °F	710°	1000°

These temperatures demonstrate the need for interpreting data rather than taking them literally, especially when sensors have not been optimally located. For example, the 800°F internal burner temperature is low when compared to the 1000°F skin temperature. In this case the low temperature is not caused by cooling by the auxiliary blower. The thermocouple is probably too far behind the burner to give a representative temperature, i.e., an internal temperature at least as high as the skin temperature. At the stack end, the newly replaced thermocouple gave meaningful readings that reflected the temperature peaks occurring when tetrytol burns.



A total of 120 M5 bursters were burned, 60 with live M557 fuses and the remaining 60 with previously deactivated M557 fuses. Each item was spaced at 40 seconds interval. The M557 fuses can be a potential trouble source because of the smallness of the cut of the M125 boosters of this fuse. The lowest 1/4" of the booster cup is sawed off, this often results in wafers of tetryl 1/8" thick. Because of their small sizes, the thin slices of tetryl or of aluminum can fall loose and are difficult to control on the conveyor. This problem will have to be addressed during the design of the finalized feed conveyor.

**E. Run 5 - 5 Jun 75, M5 Bursters and M557 Fuses recycled.** Before start-up, the stack end access door was opened to inspect the feed area. Small items can fall off the feed conveyor and miss the feed chute. These do not enter the furnace, but collect in the area behind the access door. The following were found:

1 M557 fuse

17 Tetryl - Aluminum wafers from the M125 boosters of the M557 fuses

4 small (2") pieces of the M40A1 tubes

some loose partially melted tetryl from M125 boosters

The M557 fuse seemed burned but it was recycled through the furnace as were the other items. The remaining 80 M5's of the 200 required by the test plan were burned at the rate of 30/hr. This was followed by the incineration of 40 M5's at the rate of 40/hr. Since the furnace was operated at a relatively low setting of 7/7 (oil/air) or 19 gph the change in stack temperature is impressive. The M5's with only 0.26 lbs of tetrytol gave temperatures between 680 and 740°F, the larger M71 with 2.45 lbs of Comp B raised the stack end temperature to 880 - 1000°F with two peaks reaching 1070°F. During the slow work-up of the M83 the minimum range dropped to 760-800°F but the larger pieces of the M83 (4.67 and 2.33 lbs Comp B) produced spikes that reached up to 1150°F. Because of the slow feed rate during the M83 work-up these temperature excursions had no effect on the adjacent skin temperatures. At the low temperature range that the furnace was being operated, the M83 burster remained in the retort 1 minute before starting to burn. The larger of the two pieces then required about 30 seconds to burn. This puts the piece in the second flight while it is burning, that is, all M83 sections are separated by one of the helical flights while burning.

**F. Run 6 - Jun 75 - M83.** The M83 burster is used with the M426 8" howitzer projectile. The aluminum case is 24" long with an OD of 2 11/16" and holds 7.0 lbs of Comp B. It is sawed into two sections 16" and 8" long containing 4.67 and 2.33 lbs. of explosive respectively. It is fed to the furnace at the rate of 24 per hour, i.e., one section every 75 seconds. Although either section holds more explosive than any of the other munitions components that have been incinerated, the feed rate of the M83 is such that two sections should not fall in the same flight of the retort.



The furnace was operated at a burner setting of 6.5/6.5 (oil/air). At this setting the oil consumption should have been 18 gph, but the actual feed rate was 20.6 gph which would correspond to a Hauck valve setting of almost 8. The burner temperature was also higher than would be anticipated at an oil setting of 6.5. There doesn't seem to be any real explanation for this anomalous behavior of the Hauck valve. In this case, the resulting decrease in control over the furnace operation did not have any serious consequence.

During the five hour burn the outlet conveyor jammed twelve times (10%). These were caused by the small sections (8") of the burster which was exiting from the furnace with very little heat damage. In contrast, the 16" section was either badly distorted or reduced to small pieces. The heat generated at the feed end of the furnace ranged between 800° and 1000°F during the first hour of operation. At 2.5 to 3 hours a near equilibrium state was reached in the 900° to 1150°F range. At these higher temperatures the bursters start burning within 45 seconds after falling in the retort, i.e., they start burning in the first sections instead of in the second one. This has no serious impact on the operation of the furnace other than moving the heat load close to the feed point.

G. Run 7 - 9 Jun 75 - M83. The remaining 76 M-83 bursters were incinerated at the 24/hour feed rate. There was one outlet conveyor stoppage and it was cleared with the reverse jog mechanism. After the run was finished but while the system was being operated to cool it down, there occurred a 3 second power failure. This shut off the "Systems Blower" which in turn shut off the power to the whole motor control panel. This shut down had no serious consequence since it occurred after the run, with no explosive in the system and with the burner off. Had the flame out occurred early in a run, resuming operation would have been more complicated. There is another potential source of trouble which exists with all the bursters but which is maximized with the M83's. During the handling of the sawed bursters, chips of explosive fall off the cut end. These chips are generally conical in shape and are slightly smaller than the diameter of the burster i.e., they are very small with small burster like the M-5, but they can be of appreciable size with the M-83 bursters. Provisions will have to be made to handle these chips in the design of the finalized feed conveyor.

#### IV. CONCLUSIONS

A. The M71 bursters, the M557 fuses/M40A1 bursters, M557 fuses/M5 bursters and M83 bursters have been incinerated in the APE1236 furnace without any high order pressure excursion.

B. The configuration of the munitions was the same as that produced by the burster saw station and is compatible with normal operation of the furnace.

C. Two hundred each of the M71, M557/M40A1 and M557/M5 were incinerated at the CAMDS feed rate of 30 unit/hour and 40 each at the higher "design" feed rate of 40/hour. Two hundred M83 bursters were incinerated at 24/hour.



D. The feed sequence was optimized to match the sequence of parts produced by the burster saw station.

E. Incineration temperature can be varied over a wide range in order to obtain the aluminum of the burster cases either in a molten state, or as broken "crumbs" or as whole burster tubes, depending on the most desirable configuration.

V. RECOMMENDATIONS

The final design of the CAMDS feed conveyor will have to include methods of controlling small chips of explosives used in the bursters and metal wafers from the fuses.

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## FURNACE OPERATING LOG

**APPENDIX A**

**FURNACE OPERATING LOG**

11-74  
- 35101105



29 MAY 78 - M-71

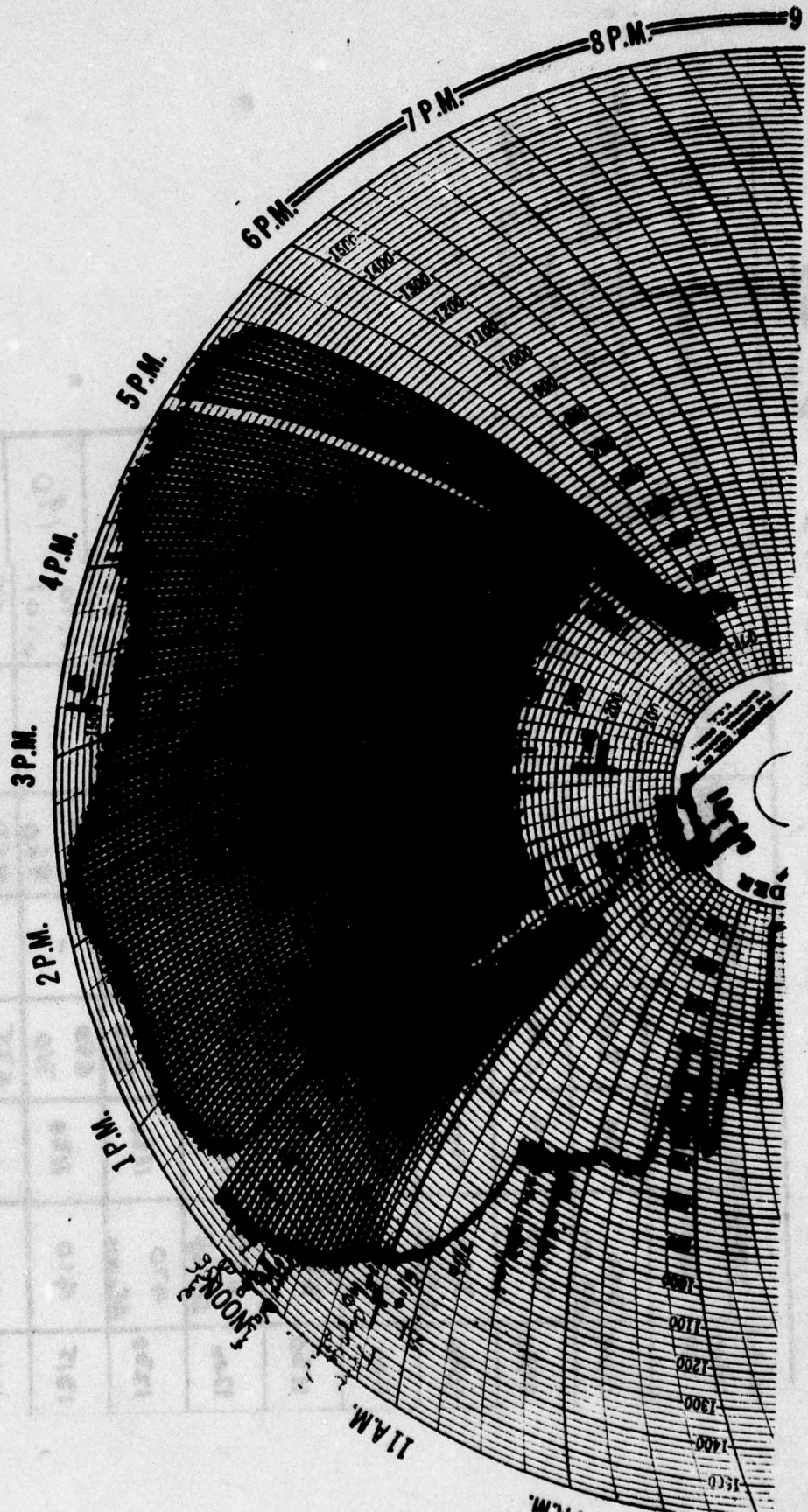
Run # 1

[illegible]



F-71

# Run #1 - Furnace Temperature Chart





# Furnace Operating Log

2 JUN 75 - M557 Furnace / M40A1 Bursters

Run #2

Start/Time	FURNACE TEMP			BURSTER TEMP			BURSTER IN	BURSTER OUT/IN	BURSTER TEMP	OIL/TEMP	OIL/TEMP	OIL/TEMP
	FURNACE	STACK	STACK	STACK	BURSTER	BURSTER						
0845	360 AS on	900	310	500	150	560	150	8.5/10	-	~600	Started feed @ 0900	
0930	360	1100	450	-	825	925	925	7.5/10	-.04	180	End of feed 1400	
1030	360 AS on	1000	540	-	820	975	975	7/10	+.02	170		
1100	360	1500	610	-	950	950	950	8.6/10	+.02	170		
1130	380	1600	610	-	930		930	"	-	170		
1200	650 AS off	1770	620	-	900	950	950	8/10	-.10	190		
1230	470 AS on	1160	675	-	825	960	960	"	-.05	210		
1315	410	1130	690	-	830	960	960	"	+.10	190		
1345	920	1240	675	840	850	970	970	"	-.05	190		
1400	420	1250	700	830	950	950	950	70/10	-.25	-		
1400	turned burner off											

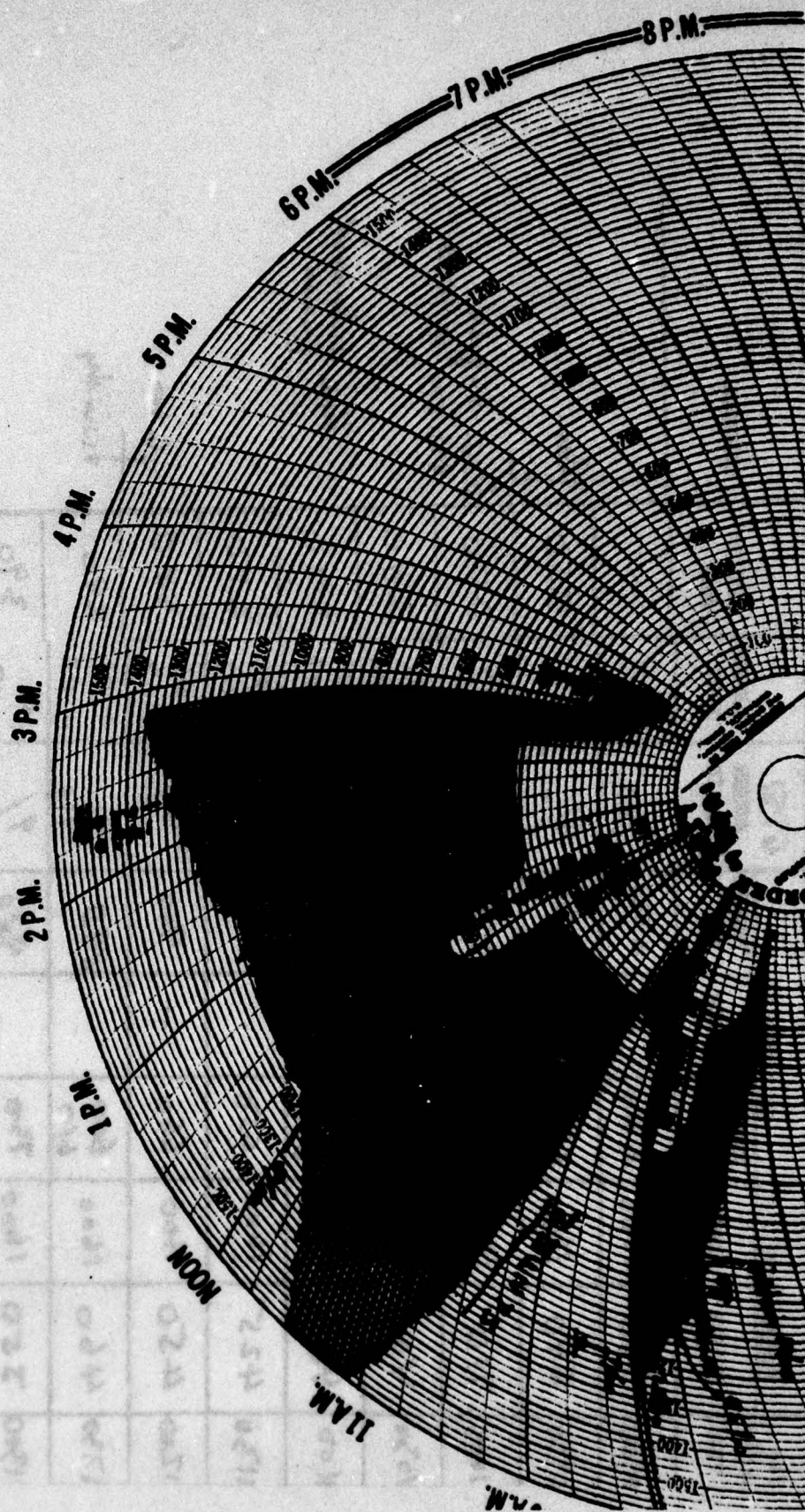
10 1

1.10" 1.2"  
OD = 1.4" ID = 1.362"



F-73

# Run #2 - Furnace Temperature Chart



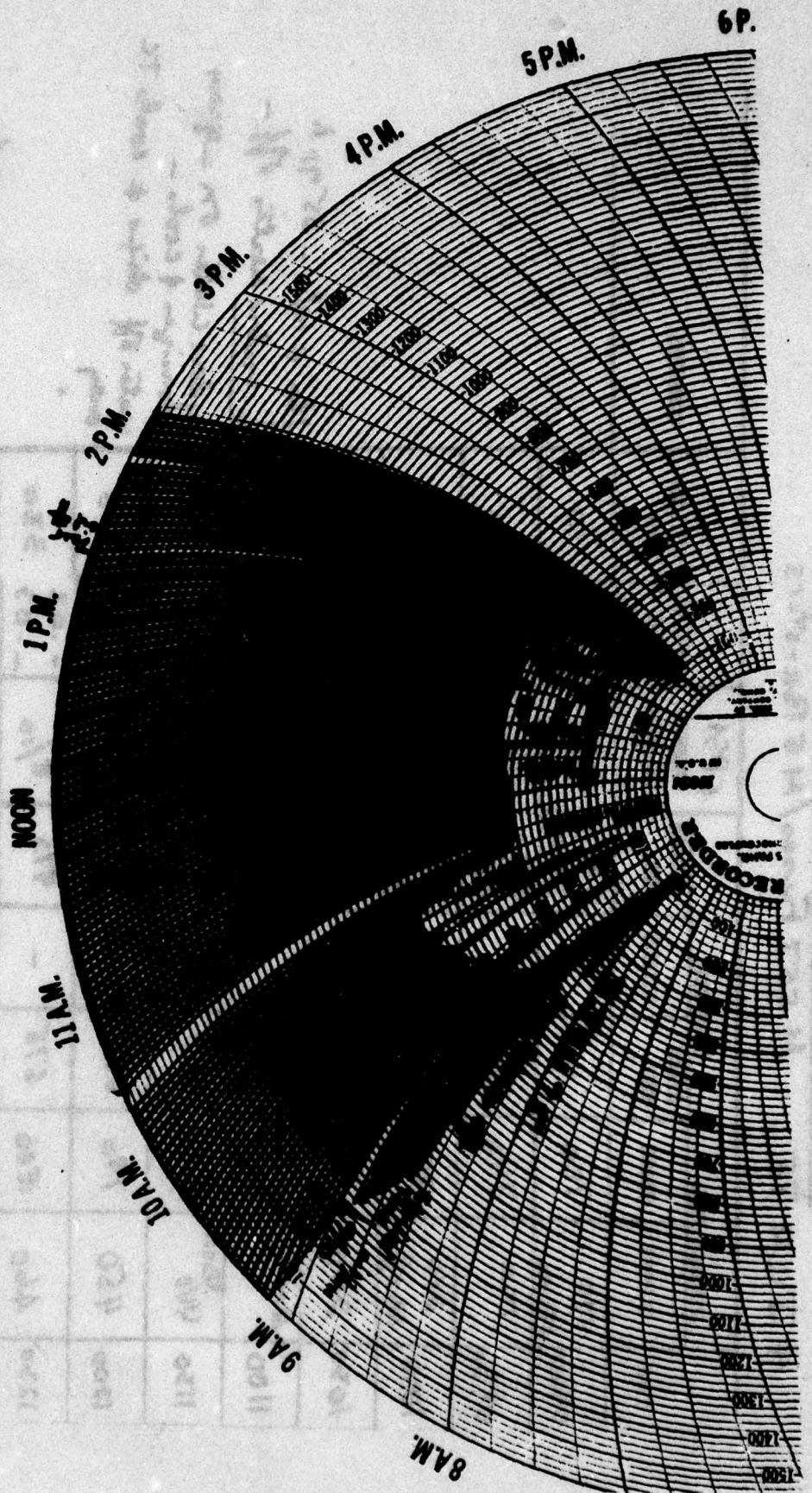


3 JUN 75 - MSS7 Fuels - M40A1 12 ursters & MS workshop

Fuel Added Time	FURNACE TIME				SEED TIME				6 PSI FURNACE OUT/INT	FURNACE TEMP	OUTLINE TEMP	COMMENT
	NUMBER	SPACE	SPACE END	SPACE END	NUMBER	SPACE END	SPACE END	NUMBER END				
0900	540	1300	1300	1300		1300	1300	1300	9/10	+01	-	
0930	640	1600	1600	1600		1600	1600	1600	9/10		350	Rain
1000	710	1600	1600	1600		1600	1600	1600	9/10	-02	250	Rain stopped 4:15 on @ 1010
1030	400	1600	1600	1600		1600	1600	1600	9/10	+01 +02	300	
1100	400	1600	1600	1600		1600	1600	1600	9/10	+01 +02	320	7/12 returned furn.
1130	425	1600	1600	1600		1600	1600	1600	9/10	-01 -02	350	
1200	450	1600	1600	1600		1600	1600	1600	9/10	+01 +02	380	Calm windy
1230	460	1600	1600	1600		1600	1600	1600	9/10	+01 -02	390	
1300	350	1600	1600	1600		1600	1600	1600	9/10	0 -02	390	
1325	oil	oil	oil	oil		oil	oil	oil				



Rm #3 - Furnace Temperature chart





Furnace Operating Log - Run # 4  
4 JUN 75 - M 557 Furnace / M 5 Bursters

TIME	FURNACE TEMP				BURST TEMP		G.P.S.I.	BURST RATE	CYCLONE TEMP	COMMENTS
	BURSTER	SPACE	SPACE	SPACE	HEAD	MIDDLE				
0900	170 1B on	700	-	-	765 750	-	10/10	- .06	90	
0930	150	740	-	-	880 800	-	10/10	- .03 - .06	90	
1000	210 1B off	750	250	-	925 975	-	10/10	- .07 - .09	100	
1030	240	730	550 575	-	975 1000	-	10/10	- .06 - .08	100	
1100	200 off	800	610 625	-	975 1000	-	10/10 8/10	0 - .02	100	
1130	440 1B on	800	650	-	970 1035	-	8/10	- .04 - .08	250	
1200	450	790	675	-	950 1000	-	8/10	- .03 - .05	320	
1230	460	800	675	-	975	-	8/10	- .02 - .03	330	
1300	500	800	710 725	-	975 1025	-	8/10	- .03 - .05	320	
1310	oil off									

3 hr @ 10/10 - 35 71 h  
 ↓ cyclone water off -  
 cyclone water on - spray  
 adjusting & cool -  
 water off drops & ends TC  
 every

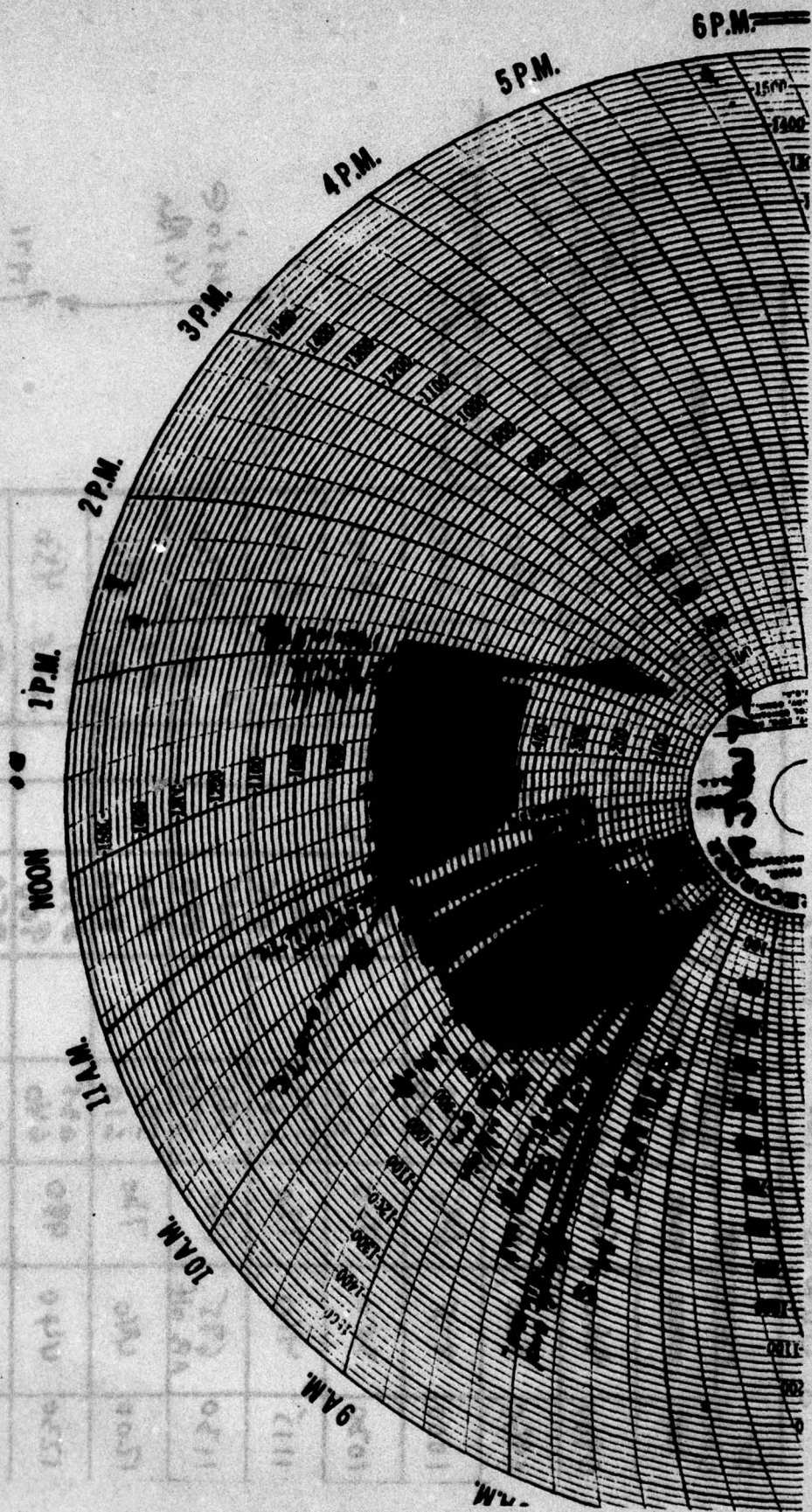
2.55 gph @ 8/10

L. 10 3/4" L. 2"  
 M. 00 3/4 ID 11/16  
 R. 00 3/4 ID 9/16



Furnace Temperature Chart - Run #4

7-77





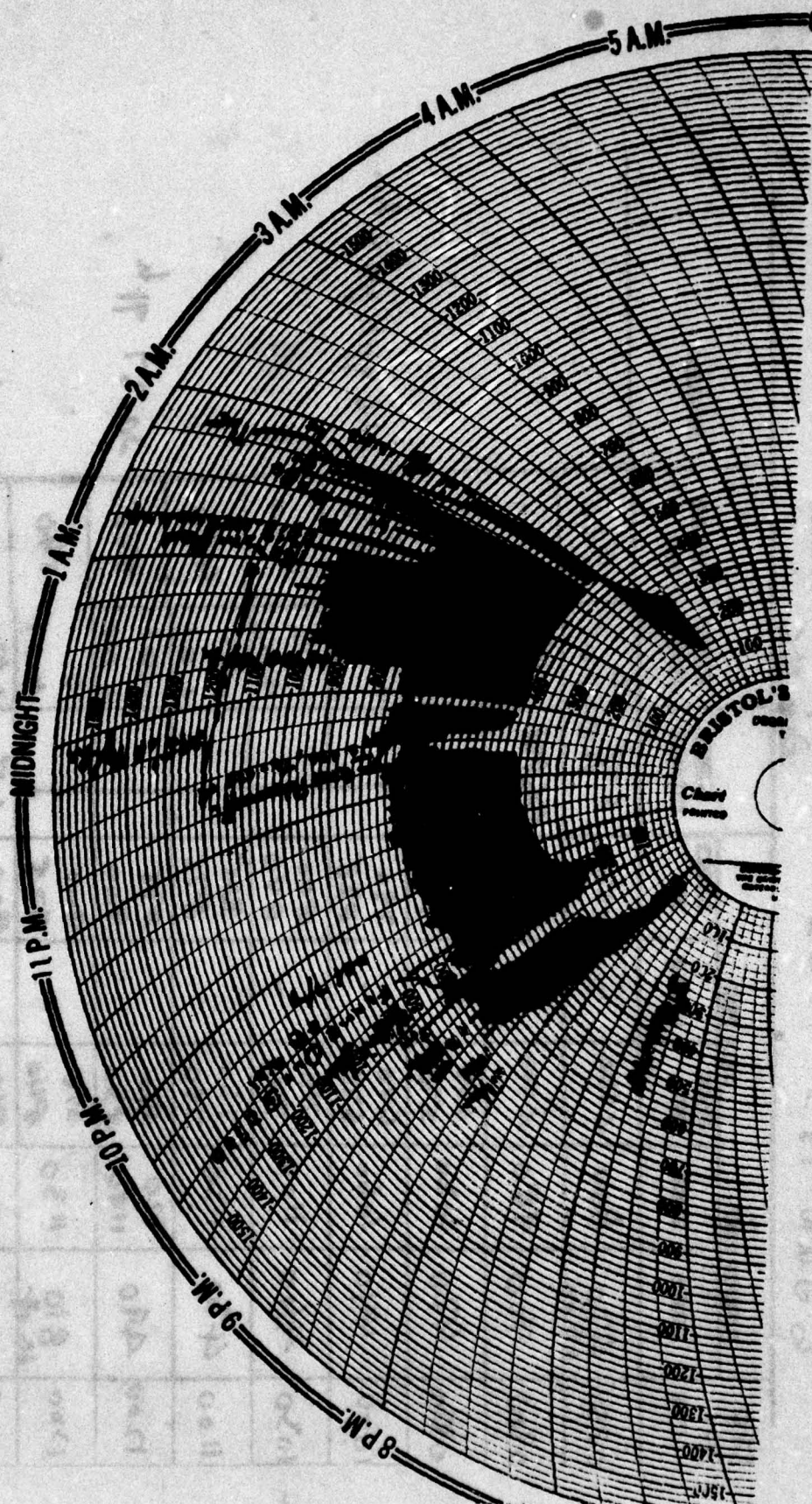
Furnace Operating Log- Run # 5

[illegible]



Furnace Temperature Chart - Run # 5

F-79





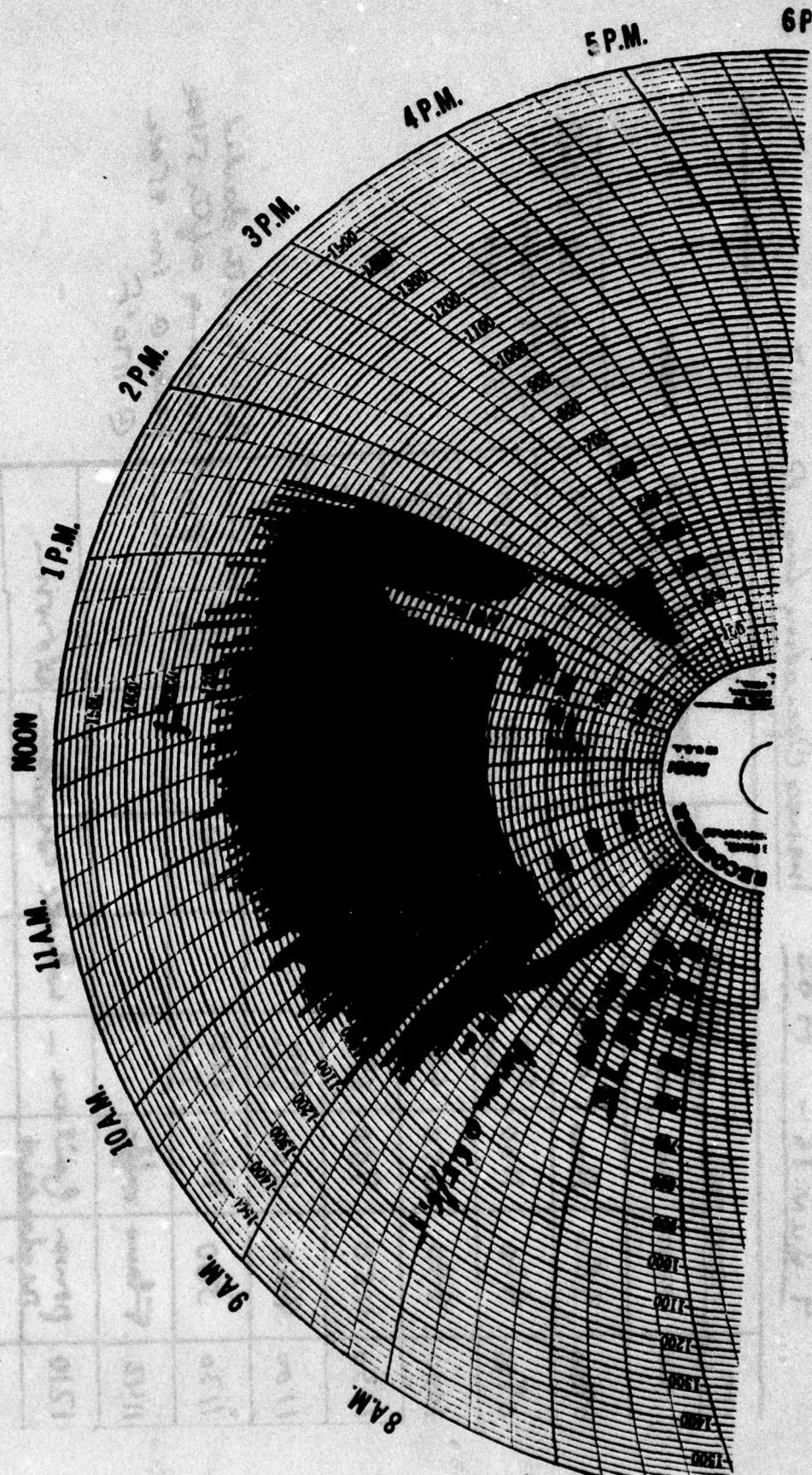
6 JUN 75 - M-83 Furnace Operating Log  
Run #6

Clock Time	Furnace Temp			Skin Temp			Furnace Oil/Air	Furnace Draft	Circulator Temp	Comments
	Inner	Stack	End	Stack	End	End				
0835	420	800	<500	-	-	<500	6.5/1.5	0	920	
0900	400	980	<500	-	-	560	6.6/1.4	-0.02	370	
0930	420	1020	550	-	-	680		+0.03	450	
1000	440	1060	640	-	-	790		+0.02	480	19.6 gph for 2 hr
1030	460	1100	710	-	-	840		-0.02	480	
1100	470	1130	760	-	-	875		-0.05	480	
1200	490	1190	810			915		+0.01	540	20.37 gph
1200	810	1130	870			925		0	540	
1235	540	1100	810			900	6.5/1.5	+0.06	540	$\bar{X} = 20.6 \text{ gph}$
	450	(1240)	840			870		-0.01		$L = 16" \text{ } 2 = 8"$ $OD = 2\frac{1}{16}" \text{ } 10 = 2\frac{3}{32}"$



Furnace Temperature Chart - Run #6

F-21





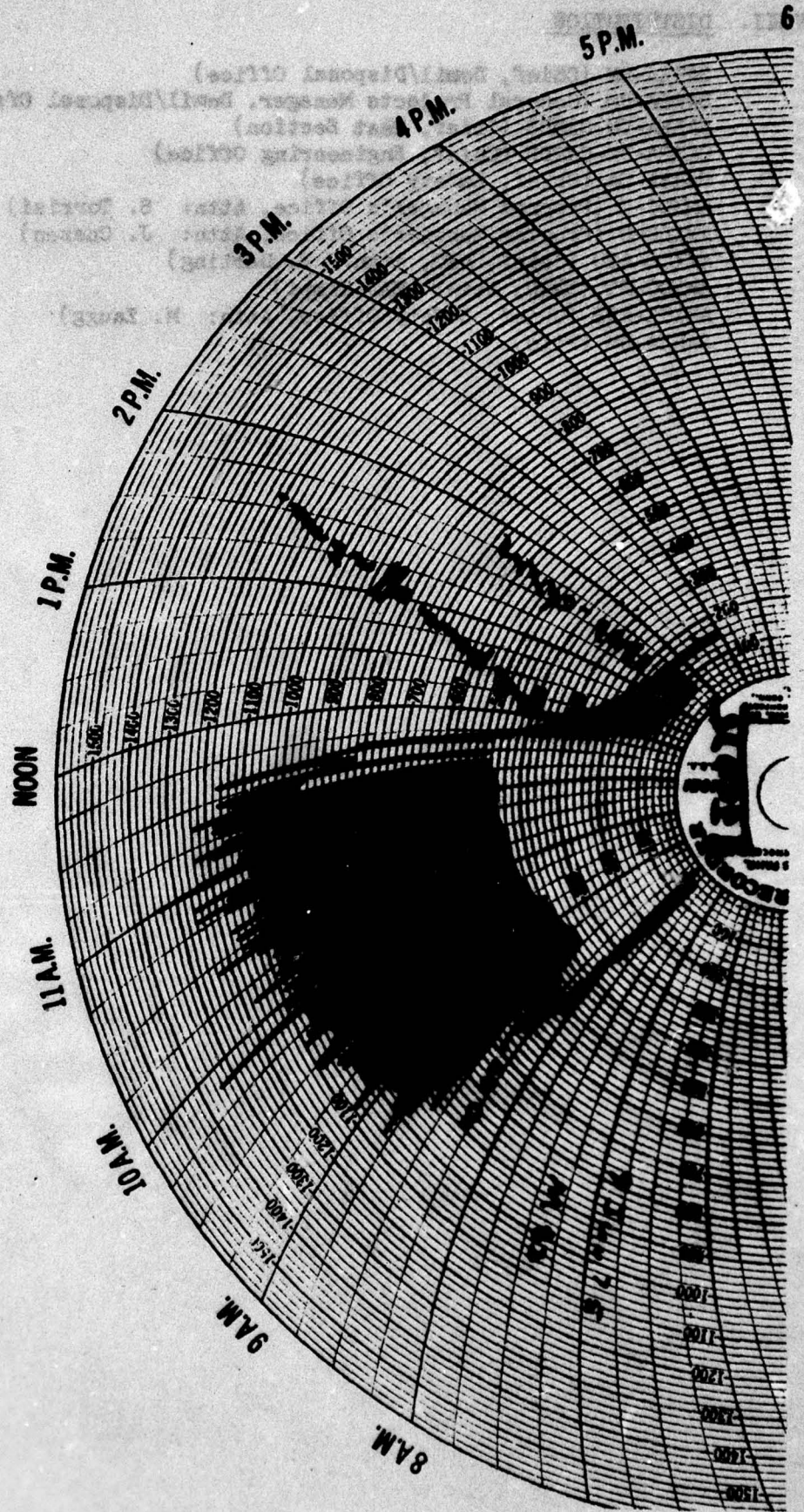
9 JUN 76 - M 83 Furnace Operating log- Run #7

[illegible]



Furnace Temperature Chart - Run #7

7.83





## VIII. DISTRIBUTION

SAREA-DM (Chief, Demil/Disposal Office)  
SAREA-DM (General Projects Manager, Demil/Disposal Office)  
SAREA-DM-CANDS (Chief, Test Section)  
SAREA-DM-CANDS (Chief, Engineering Office)  
SAREA-SA (Chief, Safety Office)  
AMKDC-T (Program Manager's Office, Attn: S. Torrisi)  
AMKDC-O (Program Manager's Office, Attn: J. Cussen)  
AMKTS-AEO (Chief, AEO, Attn: B. Darling)  
AMKDC-FT (TEAM, Attn: MAJ Timpf)  
AMKTS-ADS (Chief, Safety Office, Attn: M. Zaugg)  
SAREA-DM (File)

17. m. 9. - 10. 10. 1909

h-8-1



DEACTIVATION FURNACE  
DAAA 15-74-C-0084

DEACTIVATION FURNACE  
DAAA 15-74-C-0084

**DATA EVALUATION REPORT**  
**DATA ITEM A013**

**CAMDS DEACTIVATION FURNACE**  
**CYCLONE/SCRUBBER TESTS**  
**TOOLEE ARMY DEPOT**

Prepared by  
**SURFACE COMBUSTION DIVISION**  
**MIDLAND-ROSS CORPORATION**

Jay K. Shah

February 18, 1975

SAREA-DH: Final 4/1  
File : PC 1258

DB#3 M-R Special Report



## I. INTRODUCTION

The deactivation furnace with an air pollution control system located at the South Area Test Site of the Tooele Army Depot was designed for deactivation of explosive items from the CAMDS Demilitarization Plant. The CAMDS program for demilitarization includes a variety of munitions containing M-55 rockets. The processing of M-55 rockets represents the greatest technical challenge to the deactivation furnace system. The Government Engineers working on the project have extensively tested the furnace and the air pollution control system over the past two (2) years by burning M-61 rockets, with and without propellant. As a result of an extensive evaluation of the existing equipment and the resulting test data, several modifications were suggested by the concept design Contractor, Midland-Ross. The tests during the months of October and November, 1974 were intended to check the capability of the entire system under the most representative process conditions after incorporation of the suggested modifications. The major modifications included installation of a larger size induced draft fan downstream of scrubber and a cyclone between the furnace and the afterburner. These tests were also intended to compile design data for the future system.

The test program was divided into two (2) phases due to limited supply of whole rockets. Phase I was structured to determine scrubber efficiency by burning propellants with simulants and whole rockets were burned with simulants during the phase II period to determine particulate removal efficiency of the modified system with the cyclone in place.

## II. OBJECTIVES

The objectives as outlined in the test plan were as follows:

- (1) Determine the feasibility of using aqueous caustic solution for scrubbing to control emissions from the deactivation furnace system.
- (2) Determine the collection efficiency of the cyclone utilized for dry removal of particulate material



from the effluent gas stream from the deactivation furnace.

- (3) Determine the corrosive effects of HTH,  $P_2O_5$  and HF on different metallic materials of construction.
- (4) Determine the temperature of scrap materials leaving the retort.
- (5) Determine the quantity of unburned resin on the scrap fiberglass leaving the retort and the cyclone.
- (6) Obtain scrubber liquor for brine drying tests in potential salt dryer vendor's facilities.
- (7) Obtain data on fiberglass slagging conditions in the afterburner.
- (8) Obtain operating data relative to the safety engineering test requirements.

### III. TEST PLAN

The test plan was divided into two (2) phases, as there were only a limited number of whole rockets available for the tests. The Phase I testing involved processing of propellant with agent simulants to determine the scrubber efficiency by scrubbing with 18% caustic solution. The Phase II testing involved the processing of whole rockets with simulants to determine the particulate removal efficiency of the entire system. Two (2) separate corrosion tests, one for GB simulant and one for VX simulant with HTH, were necessary. As the total duration of the tests was short, both tests could not be accomplished. As a result, it was mutually agreed to run one corrosion test with GB simulant and HTH. The combination of GB simulant and HTH is not expected to be present in actual process, but was selected for the test purposes as a worst possible case for corrosion.

### IV. DATA REFERENCES

1. CAMDS Deactivation Furnace Test Plan for the Cyclone / Scrubber Tests, Edgewood Arsenal, 9 September, 1974.



**DEACTIVATION FURNACE  
DAAA 15-74-C-0084**

2. Test Report for CAMDS Deactivation Furnace Cyclone/Scrubber Tests, Edgewood Arsenal, 21 November, 1974.
3. Air Pollution Engineering Source Sampling Survey No. 99-006-72/75, Deactivation Furnace Tests, Tooele Army Depot, Tooele, Utah, AEHA.
4. Final Report, Analysis of Stack Samples of the Incineration of GB Rocket Parts at Tooele Army Depot, Entropy Environmentalists, Inc.
5. Test Report, Addendum #1 - Waterweb Evaluation Test Series, Edgewood Arsenal, November 20, 1974.
6. Test Report, Particulate Emission Tests, CAMDS Furnace Site, Volume I, STW Testing, Inc., September 23, 1974.
7. Test Report, Particulate Emission Tests, CAMDS Furnace Site, Volume II, STW Testing, Inc., September 23, 1974.
8. Test Report, Phosphorus Determination, STW Testing, Inc.

**V. DEVIATIONS AND LIMITATIONS**

1. The aqueous caustic solution scrubbing could not be accomplished because of several problems encountered during the test.
  - (a) The caustic pump could not be operated continuously because of the undersized overload switch.
  - (b) The fiberglass deposits in the scrubber from previous tests were causing plugging in the polyclon strainer.
  - (c) Liquid flows around the scrubber system could not be properly balanced which resulted in either an overflow from the cooling tower sump or a flooding in the scrubber sump.

As a result of all these problems, the caustic scrubbing was abandoned. The polypropylene packings from the scrubber tower were removed and a small portion of the packings was observed to be molten due to high temperature. Thus, the scrubber efficiency with 18%



aqueous caustic solution could not be evaluated during these tests and no salt solution resulting from scrubbing was collected for salt drying tests at potential salt dryer vendor's facility.

2. The afterburner operation was not satisfactory. It could not be operated continuously for a test series. The residence time in the afterburner was insufficient to achieve incineration of unburned hydrocarbons and carbon soot in the effluent gases from the deactivation furnace. The temperature of the afterburner could not be raised to the desired 1600° F level. It was suspected that the afterburner was adding hydrocarbons and unburned carbon to the gases rather than removing them.
3. An attempt was made to measure the air and fuel input into the system from various sources. The air input into the furnace burner through the combustion air blower was the only measurement that was reliable. The fuel input measurements are suspected to be incorrect. The air input through auxiliary blower and other leakage air could not be measured during these tests; but the earlier tests performed during January, 1974 have established these flows for the system with the original ID fan.

## VI. SUMMARY CONCLUSIONS

### (1) Air Pollution Control System

The scrubbing with 18% aqueous caustic solution was abandoned due to several problems encountered during the tests. Thus, no information on scrubbing efficiencies could be realized. The scrubbing efficiencies as reported in the AEMA report are only due to water scrubbing. Moreover, their measurements indicate that only a small fraction of the phosphorus and fluorine input is carried into the gaseous stream. The rest of the phosphorus and fluorine is not accounted for in the material balance. It is likely that it might have reacted with the metallic components and was retained on the walls of various deactivation furnace system components in the form of solid salts. As it is suspected that the concentration of fluorine and phosphorus in the flue gas stream at sample point #2 during these tests is not representative



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of the anticipated conditions, the final design of the scrubber system will be based on input concentrations as computed on the basis of 5% residual chemical agent. The particulate loading and size information from these tests will be useful as input data for designing the particulate removal system. Particulate removal efficiency of approximately 75% was observed between sample points #2 and #4. This particulate removal was achieved by a low pressure drop (4-6" w.c.) venturi scrubber. The final design will include a high pressure drop venturi scrubber, which will improve the particulate removal efficiency.

The overall particulate removal efficiency of the cyclone and scrubber system was about 90%. The existing system met the particulate emission standard as far as loading is concerned. The chemical analysis performed by Entropy Environmentalists for the particulate samples collected at sample point #4 indicated an average Pb concentration of 25%. Thus, the Pb emission rate was approximately 0.3 lbs/hour. Further investigation is necessary to determine if there is a threshold limit value (TLV) for Pb emissions. If the predicted emissions would exceed the TLV for Pb, then further removal of Pb particulates from the exhaust gas stream will require further study.

The plume opacity reached a peak of 100% during a given cycle of three minutes for feeding a rocket. The causes for plume opacity observed during the tests are not definitely known and further work is necessary to pin point these causes. The existing system did not have an efficient demister. The final design incorporates a demister for solving the problems of plume opacity. The size of this demister is very large and it is more expensive. The "Waterweb" demister is expected to occupy less space and would be more economical; but its effectiveness needs to be demonstrated. Thus, further testing with the "Waterweb" demister is essential to prove its effectiveness and to obtain design information if it proves to be effective.

## (2) Cyclone

The performance of the cyclone was surprisingly good, even though a very low pressure drop was measured across it. The cyclone specifications indicated a pressure



drop of 2-4" w.c., but the measurements during the tests showed that the pressure drop varied from 0.3 to 1" w.c. depending upon the gas flow rate through the cyclone. The collection efficiency of the cyclone was estimated to be about 60% as 7 lbs of particulate out of a total of 11.23 lbs was collected during run #4 and 7 lbs out of a total of 12.99 lbs was collected during run #5. The comparatively higher collection efficiency at a lower than anticipated pressure drop is attributed to a complex phenomenon. There is a possibility of thermal precipitation on the relatively cold walls of the cyclone as it was uninsulated. Another possible reason for the higher collection efficiency is the wetting of the particles upstream of cyclone by water quenching. It is also possible that the size of the particulate collected was considerably larger and therefore, would not require higher pressure drop for separation. The cyclone was designed for a gas flow rate in the range of 4600-9200 ACFM. As it was operated below its design capacity, the lower pressure drop was observed. It is essential to determine the size distribution of the particulate collected in the cyclone. The chemical analysis for the particulate collected at the sample point #2 showed a small amount of Si present. Thus, most of the glass fiber is collected in the cyclone. A chemical analysis of the particulate collected in the cyclone is necessary. It will throw some light on the presence of unburned hydrocarbons in the particulate collected in the cyclone, and will help to establish a material balance on the Pb. The final cyclone design will have a 2-4" pressure drop which will result in a greater collection efficiency.

### 3. Afterburner

Considerable difficulty was experienced with the afterburner. Several shutdowns occurred during the initial runs. A periodic shutdown indicated that the fan motor relay heater was overheating. Insulation between the control panel and the afterburner shell gave some improvement, but when the afterburner temperature was increased to 1600° F, another shutdown occurred. The shutdowns were also attributable to a defective Mercoid pressure switch in the safety circuit.

Mixing between the retort flue gases and the afterburner



**SURFACE COMBUSTION**

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combustion products appeared to be incomplete and poor incineration was the result either of poor mixing, insufficient residence time or a combination of both. Stack gas analysis at sample points #2 and #3 indicated an increase in unburned hydrocarbons and carbon monoxide from the afterburner. This was indicative of flame quenching in the afterburner or inadequate air for complete combustion. An oxygen analysis before and after the afterburner showed that the oxygen content decreased from 5% to 2%. This supports the theory of incomplete combustion.

The oil burner used on the afterburner was an air-atomizing gun type burner similar to those used for firing small boilers and space heating furnaces. A portion of the combustion air was admitted through a louvre linked to the fuel control valve. No direct means for air flow measurement is possible with this system. The usual method for determination of air flow in this kind of system is to meter the fuel flow and establish air flow by analysis of combustion products ( $\text{CO}_2$ ). Installation of a separate oil supply tank and metering system for the afterburner did not provide information concerning the oil input to the burner because of operating problems. Government engineers have corrected the system and are now in a position to measure the oil input to the afterburner. Midland-Ross Engineers, experienced in the design of the afterburners, feel that the information regarding the oil flow to the existing afterburner is not of critical importance in the final design. Thus, no specific tests are necessary to obtain oil flow information to the afterburner.

The information obtained on the afterburner operating characteristics during these tests will not be useful for final design purposes except to call attention to specific areas of concern where major design improvements are required. These include:

- (a) Thermally insulated control panel.
- (b) Most of combustion air supplied through a burner.
- (c) Afterburner designed for improved mixing characteristics.
- (d) Residence time should be 1/2 second.



- (e) Afterburner designed for operation at 1500-1600° F or higher, if incineration of carbonaceous particles is required.

During a previous inspection of the afterburner internals, loose bricks were found at the bottom which were coated with a glassy slag. It was assumed to be molten fiberglass. An analysis of this slag is still pending. Brick samples were not collected after the tests during September and October, 1974. A brick sample should be pulled from the afterburner for examination. It is suspected that the fiberglass entering the afterburner with the gas stream would melt in the temperature range of 1500-1600° F, and form a slag on the refractory lining. Due to the limited maximum temperature and residence time in the existing afterburner at Tooele, this phenomenon may not occur. A laboratory piloting program at the Surface Combustion R & D Laboratory for a slagging afterburner will conclusively determine the possibility of slag formation and will furnish the design data, if a slagging afterburner is required.

#### 4. Deactivation Furnace

##### a. Material Handling

Removal of the obstructions at the charge end of the retort, installation of the reverse jogging mechanism on the conveyors and other minor modifications has resulted in a more reliable operation than experienced in earlier piloting. We were able to run the rocket sections over a period of several hours with either no difficulty or only minor problems which were easily cleared without requiring a furnace shutdown. In later tests it was reported that some discharge conveyor problems resulted from molten aluminum collecting between conveyor segments.

The final design will provide for a greater angle of approach in the feed chute and a wider opening at the charge end should prove to be more effective in maintaining the continuity of the feeding operation. The discharge chute with a wider divergence angle will minimize discharge material blockages. It will be necessary to give additional attention to



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the design of a means for removal of molten aluminum from the retort discharge before the material reaches the discharge conveyor.

### **b. Sequential Charging**

Rocket components were fed to the retort on a three minute cycle using an approved CAMDS sequence as modified by field testing (CAMDS Test Report, November 21, 1974, page 5). Rocket burns proceeded smoothly with no evidence of high order reactions. The burning rate was low enough that the minimum oxygen content of the flue gases from the deactivation furnace did not fall below 5%. The test results showed that the charging sequence used would be satisfactory for the final design furnace operation.

### **c. Sources and Flow Rates of Air Inputs**

The intake of the combustion air blower was disconnected from the furnace seal leakage housings and an extended and orificed blower intake duct was provided. Pilot surveys were run both in the combustion air blower intake duct and the auxiliary air blower duct. A flow rate of 275 SCFM for combustion air was measured with the Hauck air control valve nearly open. This flow rate is in close agreement with an earlier measurement of 309 SCFM as reported in the STW Test Report Volume II. Pilot tests in the auxiliary air duct were unsuccessful because of the low velocity in the duct. Earlier tests with an anemotherm showed a measured flow rate of 695 SCFM through the auxiliary air duct. Air leakages at the feed and discharge ends were not measured, but earlier tests with the former I.D. fan have measured these flow rates to be 228 SCFM from the feed end and 105 SCFM from the discharge end. A considerable amount of judgement is required in evaluating this flow rate information from different tests based on different pieces of equipment. The final design flow rates, based on theoretical calculations, are comparatively higher and will provide adequate supply of air to the system in a more controlled fashion. It will result in a more efficient thermal operation.

### **d. Flow Stratification**

Auxiliary air added semi-tangentially around the burner



flame appeared to mix very slowly with the oil flame. The temperature indicated by the furnace temperature control was reduced substantially by auxiliary air. A large temperature rise was obtained at the same firing rate when the auxiliary air was shut off. The stratification problem at the burner end will be eliminated in the final design by putting most of the combustion air through the burner.

Additional stratification was observed in the discharge stack showing poor mixing between the charge end infiltration air and combustion products from the retort. The gas temperature in the exhaust duct from the deactivation furnace cannot be measured accurately unless the gases are thoroughly mixed. As the flow of infiltration air from the charge end will be controlled by the temperature of the effluent gases in the final design, the mixing of the gases with infiltration air is important and location of the thermocouple measuring the temperature is very critical. The baffled duct with a thermocouple farther downstream will result in a controlled operation.

e. Fuel Input

During the initial propellant and total rocket burns fuel for both the retort and the afterburner was metered at the outlet of a single fuel storage tank. As the metering system was not functioning properly, it was decided to use two (2) storage tanks, one for the furnace and one for the afterburner, so that the average consumption rate could be calculated for each burner by measuring the change in the oil level in each tank. We were forced to change back to a one (1) tank system because of the operating problems encountered with the two (2) tank system. Government engineers have solved the problems associated with the two (2) tank system and are now in a position to measure the oil flow rate to the individual burners. Midland-Ross feels that the fuel input data from the tests is not of critical importance, as the final design is based on a higher burner end temperature. Further testing specifically for oil flow rates is not essential.

f. Retort and Gas Stream Temperatures

The retort external skin maximum temperatures were



measured at 760° F for the burner end and 830° F for the stack end after about three hours running time on total rocket burns. The internal skin temperature would be in the range of 800 - 900° F. Insulating the burner end retort section, as suggested in the final design, will cause the burner end temperature to reach the desired level of 1000 - 1100° F to complete burning of the fiberglass resin. The design decision for convection cooling of the charge end retort section is justified on the basis that cooling of comparatively hotter charge end section is essential to prevent thermal shock to sensitive munition components at the charge end.

As mentioned previously, the control temperature at the burner end is consistently low because of the cooling effect of the auxiliary air. The low temperature region around the flame would also have an adverse effect on our ability to heat the rocket parts to 1000° F and complete the combustion of fiberglass resin. This problem will be solved by putting in most of the combustion air through the burner (excess air burner), and minimizing leakage air.

The stack end gas temperature reached a peak of 1750° F when burning total rockets and over 2000° F when burning only propellant. The temperature of the stack gases must be reduced to the 1400 - 1500° F range to minimize oxidation and corrosion damage to the metallic components and prevent melting of fiberglass particulate in the duct or cyclone. The final design has provision for adding infiltration air at the charge end in a controlled fashion to regulate the temperature of effluent gases from the deac furnace.

g. Amount of Unburned Resin

The color and appearance of the fiberglass discharged from the retort indicated that the fiberglass resin was not completely burned. The final design has increased the length of the retort to provide more residence time and provision for increase of the burner and temperature is included. These improved features in the final design will enable complete burning of the fiberglass resin within the retort.



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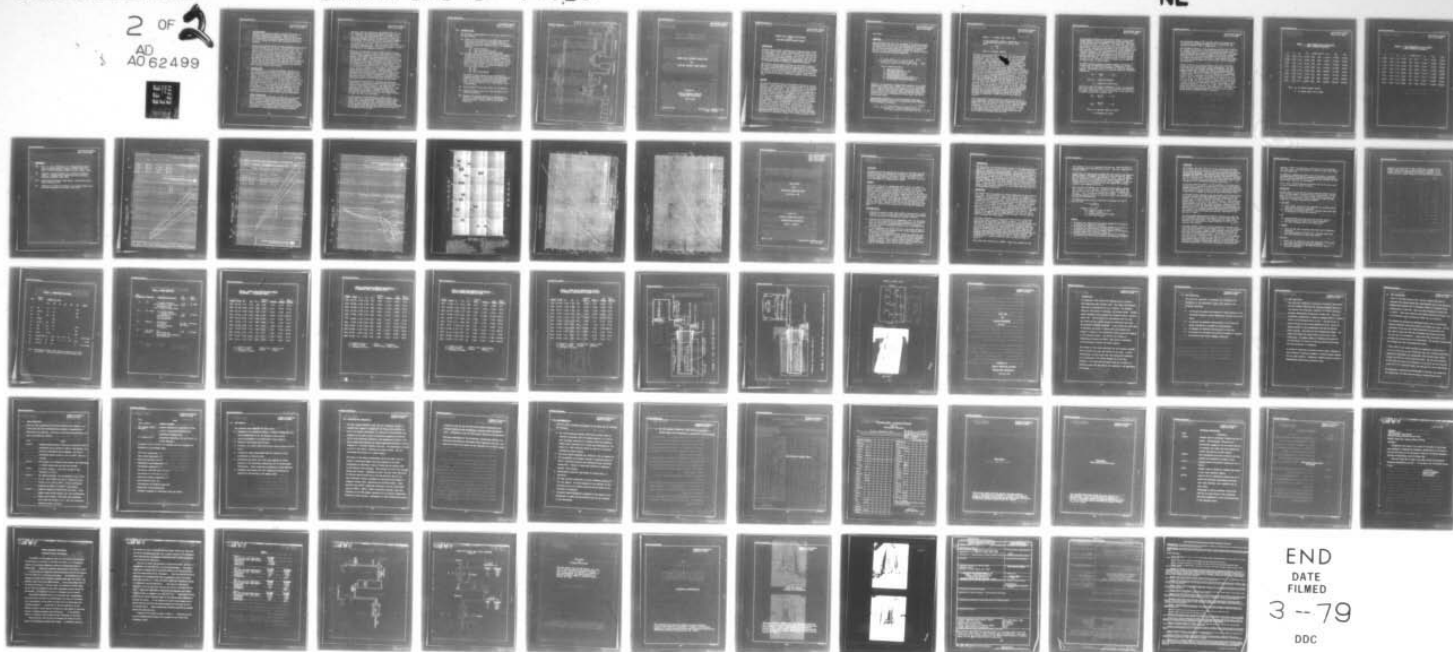
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### 5. Corrosion Data

Fourteen (14) different metallic coupons were tested for corrosion resistance and corrosion rates as high as 8400 MPY observed in Hastelloy-C. There was an evidence of liquid phase corrosion and further work is being carried out to study the liquid phase corrosion using metallography.

The time during which the GB simulants and HTH were fed to the furnace was short (7 3/4 hours). The short time period was used for the calculations of the corrosion rates. The samples were in position during the tests involving no simulants in addition to the tests involving simulants. Thus, the rates are considerably higher and should not be used for quantitative purposes. The relative comparison of all the samples indicated that NI 200, INC 600, INC 825, and INC 671 are the most satisfactory among the tested materials. Further testing with several other materials is warranted and the test duration should be increased to 100 hours for more reliable quantitative results.

### 6. Waterweb Test

A 1/2" thick 5 x 5 mesh waterweb demister was tested for its effectiveness in removal of the plume opacity due to fine mist generated by incineration of rockets with simulants. Two (2) pieces of size 16" x 48" waterweb were installed in a V shape within the Teller Scrubber demister section and were operated dry. No appreciable change in the plume opacity was observed. It is very likely that waterweb demister would be more effective if operated wet rather than dry. It is also essential to determine the cause of plume opacity. A test with trimethyl phosphite only and a test with benzotrifluoride only would be helpful in determining the cause of plume opacity. The causes, other than phosphorus and fluorine should also be investigated.

### 7. Safety Engineering

It is of significant importance to note that no high order detonations were observed during the entire processing series for M 61 rockets in the APE 1236 deactivation furnace. Several hundred rockets were burned prior to October, 1974 and 90 whole rockets were burned during the test period of 04 October to 09 October, 1974 without any high order detonations. During the processing of bare propellant



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sections, flame was observed in the effluent gas duct and the temperature was higher than  $2000^{\circ}\text{F}$  at sample point #1. Even with the high temperature and flame in the duct work, the propellant did not go high order. During the processing of whole rockets, the burning rate was comparatively slower; but peak temperatures as high as  $1750^{\circ}\text{F}$  were detected at the sample point #1; but no high order detonations were observed. The final design has provision for cooling the effluent gases. Thus it will increase the relative safety of the deactivation system.

There was an indication of very slight positive pressure during periods of rapid burning of propellant as registered by the inclined manometer used to measure the draft in the furnace. The reading was instantaneous and could not be measured accurately. Puffing of smoke from the furnace was not observed. There is a possibility that rapid burning of propellant causes a surge and drives the liquid column in the manometer to the positive side by sudden impact. Thus, the instantaneous reading would not be truly representative of the pressure conditions in the furnace. The existing system can be considered to be marginal regarding the draft conditions in the furnace. The final design has incorporated some modifications for control of leakage air and the I D fan is properly designed for the flow rates and pressure drops in the system. These modifications will definitely improve the draft conditions in the furnace.

Gas samples were collected by following the continuous oxygen trace. Instantaneous samples during low oxygen content were collected and analyzed. The worst case was 4.64 %  $\text{O}_2$  with 2.08%  $\text{CO}$  during the 04 October test. This concentration is outside the flammability limits and no fire hazards are involved. Moreover, the final design provides for greater ventilation with more oxygen and will be safer than the existing system.

A wood platform for gas sampling at sample point #1 had caught fire, as it charred and ignited due to high temperature of the effluent gas duct. Charring of the wooden rafters in the vicinity of the duct from the afterburner to the scrubber also was noticed. The duct will be insulated in the final design and wood components in the vicinity of hot surfaces will be avoided.



**VII. RECOMMENDATIONS**

The following recommendations are made after evaluation of the test results:

- (1) Further 100 hour definitive corrosion tests should be carried out either on a laboratory scale or a pilot plant scale for longer duration to obtain more reliable quantitative corrosion rates. The suggested tests are:
  - (a) With GB simulant
  - (b) With VX simulant and HTH.
  - (c) With high test Hypochlorite (HTH)
- (2) Further "Waterweb" demister tests should be conducted to verify its effectiveness, to pin point the cause of plume opacity and to obtain design information if it proves to be effective for the system. A 2" thick waterweb demister with a mixture of 8 x 8 and 10 x 10 mesh screens is preferable to the earlier 1/2" thick with 5 x 5 mesh screen. It should be checked with three (3) modes of operation:
  - (a) Dry
  - (b) Wet
  - (c) Wet intermittantly.

The cause of plume opacity can be pin pointed by burning propellants in the furnace with only trimethyl phosphite initially and then with benzotrifluoride only. Burning only propellants would indicate if there is any contribution to the plume opacity from the propellant.

- (3) Check threshold limit value (TLV) for Pb emission.
- (4) Analyze the cyclone catch for size distribution and chemical composition.
- (5) Establish the slagging behaviour of fiberglass by analyzing a brick from the existing afterburner and also by laboratory studies scheduled at Surface Combustion.







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**DEACTIVATION FORM 100**  
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**REPORT BLAST STRENGTH CALCULATIONS**  
**FOR**  
**SAFE AND ULTIMATE CHARGE WEIGHTS**

**RECEIVED**

The safe weight is defined as the maximum weight of TNT which can be safely handled without the risk of explosion. This weight is the weight of TNT which can be safely handled without the risk of explosion. This weight is the weight of TNT which can be safely handled without the risk of explosion.

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**Prepared by**

**SURFACE COMBUSTION DIVISION**  
**MIDLAND-ROSS CORPORATION**

**Jay K. Shah**

**March 18, 1975**

**Distribution: DAAA-DM (1/1)**  
**File: FC-1258**



**RETORT BLAST STRENGTH CALCULATIONS  
FOR  
SAFE AND ULTIMATE CHARGE WEIGHTS****DEFINITIONS:**

The safe charge weight is defined as the maximum weight of TNT in pounds which can be safely exploded within the retort without any damage to the retort walls. This implies that the pressure developed during this explosion will be such that the retort walls would be deformed within the elastic range only and thus the retort will be capable of taking several of this type of explosions without creating any operational problems.

The ultimate charge weight is defined as the maximum weight of TNT which can be exploded within the retort without rupturing the retort walls; but there will be significant amount of plastic deformation of the walls which will cause problems in the operation of the retort and will necessarily require replacement of the sections of the retort which have undergone plastic deformation.

**PURPOSE:**

The army has installed several deactivation furnaces at various locations. These furnaces have a standard design of 36" outside diameter, 20 ft length and 2" wall thickness and are constructed from low alloy steel (WC-9). The standard design of the army for deactivation furnaces has been modified for the CAMDS system because of several reasons. The diameter and length have been increased to 48" and 30 feet, respectively, to provide more residence time and the material construction is changed to provide more strength at elevated temperatures and to provide more corrosion resistance. It is very essential to establish the relative strength of new design in comparison to the existing design. Moreover, the ultimate charge weight calculations can be compared with the actual experience at the Rocky Mountain Arsenal. If the calculations for the existing design are in agreement with the actual performance at Rocky Mountain Arsenal, then the calculated value of the ultimate charge weight for the new design will serve as a reasonable estimate of the blast strength of the



new retort.

**NARRATIVE:**

More definitive data have been developed by the Naval Ordnance Laboratory (NOL) for water-filled cylinders where a wide range of materials and vessel sizes were investigated (Reference 1). The following theoretical/empirical equation was developed to express the safe containable charge weight  $W$  in terms of vessel size and conventional material properties.

$$W = \left[ \frac{0.1536 e_w^{0.85} (0.41 + 0.117 R_i/h_o) (R_o^2 - R_i^2)^{1.85}}{10^5 (\sigma_y + \sigma_o + \sigma_u e_u)^{-1} (1.47 + 0.0373 R_i/h_o)^{0.18} R_i^{0.78}} \right]^{0.811} \quad (1)$$

where the nomenclature and units are:

$W$	charge weight (pentolite), lb
$w$	weight density of vessel material, lb/in <sup>3</sup>
$R_i$	initial internal radius of vessel, ft
$R_o$	initial external radius of vessel, ft
$h_o$	initial wall thickness of vessel, ft
$e_u$	conventional ultimate strain of vessel material, in./in.
$\sigma_y$	conventional yield stress of vessel material, psi
$\sigma_u$	conventional ultimate stress of vessel material, psi

Equation 1 is applicable to water-filled cylinders with length/radius ratio greater than or equal to 4, and it is considered safe in light of end constraints, welding, and material variations. NOL also found that for empty cylindrical vessels (containing only air at atmospheric pressure) the safe weight or explosive that may be contained is at least twice that for a water-filled vessel.

Applying TNT equivalency of 1.15 for pentolite and using a multiplication factor of 2 for air containing vessel, Equation 1 can be expressed as follows:

$$W = 2.3 \left[ \frac{0.1536 e_w^{0.85} (0.41 + 0.117 R_i/h_o) (R_o^2 - R_i^2)^{1.85}}{10^5 (\sigma_y + \sigma_o + \sigma_u e_u)^{-1} (1.47 + 0.0373 R_i/h_o)^{0.18} R_i^{0.78}} \right]^{0.811} \quad (2)$$



where  $W$  = charge weight (TNT), lbs.

If the containment vessel is permitted to be deformed only within the elastic limit, then

$$u = \frac{\sigma}{E}$$

where  $E$  is elastic modulus.

The safe charge weights ( $W$ ) for retorts with 48 inch outside diameter and different wall thicknesses are calculated applying Equation 2 for five different materials and are plotted in Figure 1. These calculations are based on the strength properties which are listed as minimum requirements for these materials. Thus, the safe charge weight handling capabilities for these materials are more conservative figures. If the strength properties for as-cast materials are used in the calculations, then the safe charge weight handling capabilities for each material is comparatively higher than the previously calculated values for the same material. The new values are plotted for three different materials in Figure 2. The alloy HK40 has the highest strength of 0.54 lbs of TNT among all the materials investigated. The existing design has a 36 inch outside diameter and 2" thickness and the material of construction is a low alloy steel (WC-9). The calculated strength for the existing retort on the basis of minimum ASTM strength requirements is 0.234 lbs of TNT and on the basis of as-cast strength properties, it is 0.272 lbs of TNT. Thus, the new design with 48 inch o.d., 2" wall thickness and HK40 as the construction material has twice the capability of the existing design. Moreover, the allowable stresses at 1100°F are 12,000 psi for HK40 in comparison to 4,000 psi for WC-9 as shown in Figure 3.

All of the previous calculations are limited to centrally located explosions. However, the expected explosion can occur at points other than the centroid of the retort. Here the impulse loading at any particular area closest to the explosion will be greatest, but the overall uniformly distributed load will be less severe than the centrally located explosions. Thus, a safe charge weight for centrally located explosions may not be safe if it explodes near the wall.



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If we restrict ourselves to the elastic response of the retort during explosion, then the response time of the structure is usually smaller than the duration of the shock wave. The safest design criterion, in this case, is to treat the peak reflected pressure as the static load and limit all stresses in the retort to the material yield strength. The plastic response time of a structure is generally large, compared to the duration of reflected shockwave. For cases where it is acceptable for the retort to undergo plastic deformation to utilize its full containment potential, the most important blast parameter becomes the reflected impulse. The stresses can go up to the ultimate strength and the ultimate strength increases by 25 to 50% due to dynamic effect of rapid loading.

The peak reflected pressure, reflected impulse, and duration of shock wave are obtained from Figure 4 (Reference 4) for a 3 ft O.D. retort with 2" wall thickness for different explosive loading. The pressure ( $P_i$ ) due to impulse loading is calculated by Equation 3.

$$P_i = \frac{2 i_r}{t_o} \quad \text{--- (3)}$$

where  $i_r$  = reflected impulse

$t_o$  = duration of shock wave

The hoop stresses for elastic deformation ( $\sigma_{he}$ ) are calculated using peak reflected pressure as static load and hoop stresses for plastic deformation ( $\sigma_{hp}$ ) are calculated using pressure due to impulse loading ( $P_i$ ) as static load.

$$\sigma_{he} = \frac{P_r \times R}{t} \quad \text{--- (4)}$$

$$\sigma_{hp} = \frac{P_i \times R}{t} \quad \text{--- (5)}$$

where  $R$  is internal radius of retort

$t$  is thickness of retort



The calculated values of  $\sigma_{he}$  and  $\sigma_{hp}$  for a 3 ft retort and a 4 ft retort are compiled in Tables 1 and 2, respectively and plotted in Figures 5 and 6, respectively. The allowable stresses at room temperature for WC-9 are 17,500 psi. If a safety factor of 1.5 is used for designing purposes, then the stresses should be limited to 11,670 psi for WC-9. The charge weight of TNT generating hoop stresses of 11,670 under elastic deformation for 3 ft retort from Figure 5 is 0.23 lbs and for 4 ft retort from Figure 6 is 0.41 lbs. These values are in agreement with calculated values of 0.234 lbs and 0.370 lbs obtained from Equation 2.

Figures 5 and 6 can be used to evaluate the total containment capability of the retorts under plastic deformation. The low alloy steel WC-9 has ultimate strength of 70,000 psi and under dynamic loading due to shock, the ultimate strength would increase by 25%. Thus, the ultimate strength would be 87,500 psi. A charge weight of 2.35 lbs of TNT is required to generate hoop stresses of this magnitude under plastic deformation for a 3 ft retort. Thus, the ultimate capability of the existing retort is 2.35 lbs of TNT. An explosion from a charge weight of more than 2.35 lbs of TNT will not be totally contained by existing retort. A similar analysis for HK40 with 4 ft O.D. retort shows a total containment capability of 4.37 lbs. of TNT. These capability values are based on strength at room temperature. At higher temperatures the ultimate strength would be lower and the charge weight handling capability would be reduced.



TABLE 1 - HOOP STRESSES FOR 3 FEET RETORT  
WITH 2 INCH WALL THICKNESS

w	d	d <sub>s</sub>	P <sub>r</sub>	i <sub>r</sub> /w <sup>1/2</sup>	t <sub>o</sub> /w <sup>1/2</sup>	P <sub>i</sub>	σ <sub>he</sub>	σ <sub>hp</sub>
.512	1.33	1.62	2,600	160	.100	3,200	20,800	25,600
1.000	1.33	1.33	3,900	220	.080	5,500	31,200	44,000
1.33	1.33	1.21	4,700	250	.072	6,950	37,600	55,600
1.73	1.33	1.11	5,500	285	.067	8,500	44,000	68,000
2.20	1.33	1.02	6,600	330	.063	10,500	52,800	84,000
2.74	1.33	0.95	7,700	370	.060	12,350	61,600	98,800
3.38	1.33	0.89	8,800	410	.058	14,100	70,400	112,800
5.50	1.33	0.74	12,500	550	.054	20,400	100,000	163,200

Note: d<sub>s</sub> is scaled distance (d/w<sup>1/2</sup>)

w is charge weight (lbs of TNT)

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DAAA 15-74-C-0084TABLE 2 - HOOP STRESSES FOR 4 FEET RETORT  
WITH 2 INCH WALL THICKNESS

w	d	d <sub>s</sub>	P <sub>r</sub>	$t_r/w$	$t_o/w$	P <sub>i</sub>	$\sigma_{he}$	$\sigma_{hp}$
0.512	1.83	2.29	1,200	100	0.23	870	13,200	9,570
1.00	1.83	1.83	2,000	140	0.125	2,240	22,000	24,640
1.33	1.83	1.66	2,500	160	0.105	3,047	27,500	33,520
1.73	1.83	1.53	2,900	180	0.094	3,829	31,900	42,120
2.20	1.83	1.41	3,500	200	0.084	4,762	38,500	52,380
2.74	1.83	1.31	4,000	225	0.078	5,769	44,000	63,460
3.38	1.83	1.22	4,600	250	0.072	6,945	50,600	76,395
5.50	1.83	1.03	6,600	330	0.064	10,312	72,600	113,432

Notes: d is scaled distance (d/w)

w is charge weight (lbs of TNT)

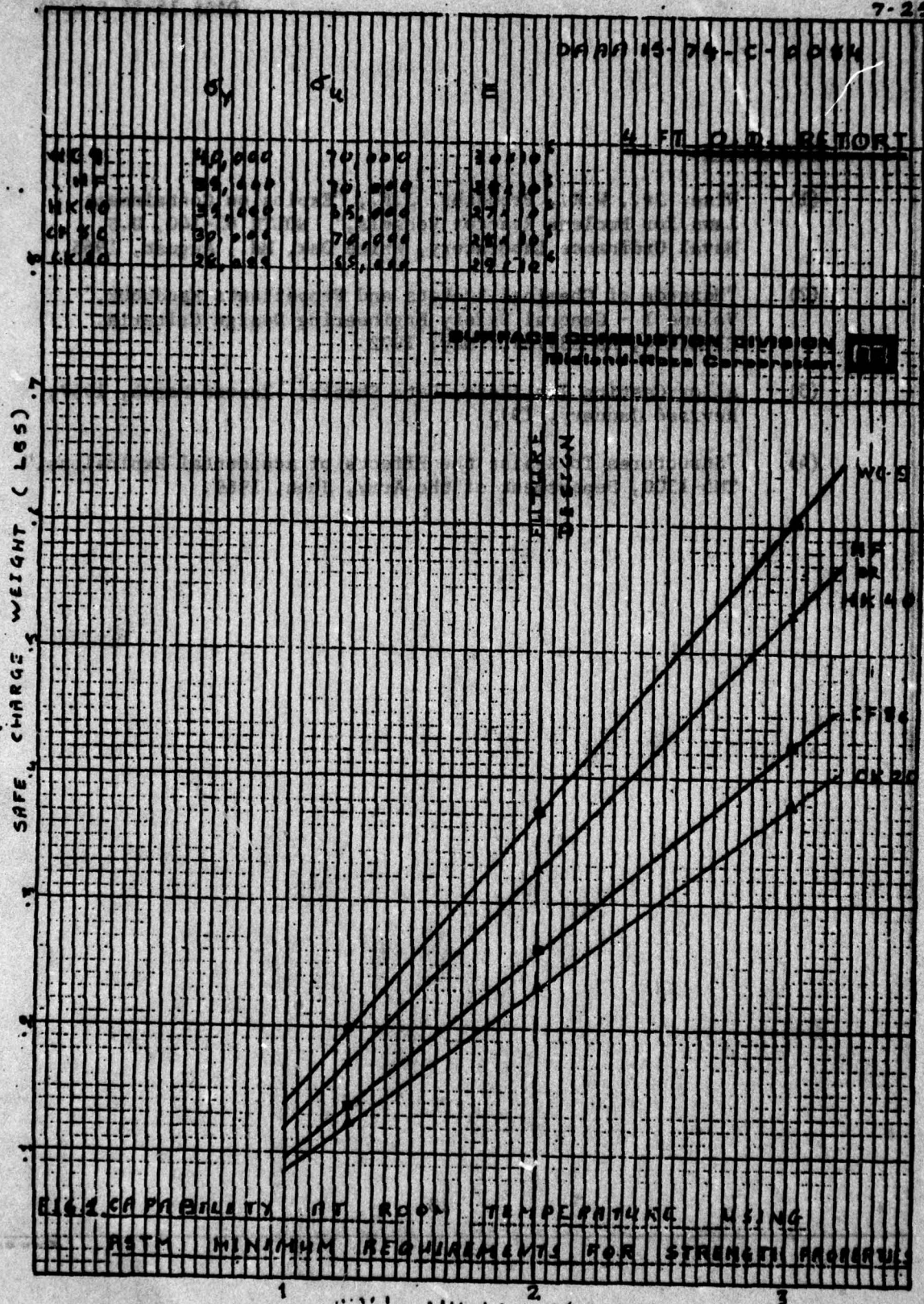


**REFERENCES:**

- (1) Wise, Jr., W.K., Procetor, J.P., "Explosion Containment Laws for Nuclear Reactor Vessels," NOLTR 63-140, U.S. Naval Ordnance Laboratory, White Oak, Md., August, 1965.
- (2) "Hazards of Chemical Rockets and Propellants Handbook," Volume I - General Safety Engineering Design Criteria, CPFA/194, AD 889763, May, 1972
- (3) Alloy Casting Institute, Data Sheets, Issued March, 1957, Revised January, 1973.
- (4) "Structures To Resist the Effects of Accidental Explosions," TM5-1300, Department of the Army, June, 1969.



KE 10 X 10 TO THE INCH 48 0703  
7 1/2 INCHES  
REPROD. & EDISON CO.



JKS  
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DAAG 15-74-C-0084

4 FT O.D. RETORT

FIG. 2 CAPABILITY AT ROOM TEMPERATURE  
USING STRENGTH PROPERTIES  
FOR MS CAST MATERIAL

SAFE CHARGE WEIGHT (LBS TNT)

	$\sigma_y$ (psi)	$\sigma_u$ (psi)	E (psi)
HK40	50,000	45,000	27.5 $\times 10^6$
LF	45,000	40,000	28.5 $\times 10^6$
WC9	45,000	40,000	28.5 $\times 10^6$

HK40

LF

WC9

FINAL DESIGN

SURFACE CORROSION DIVISION  
MILLEN-ROSS CORPORATION



ALL DIMENSIONS IN INCHES

F-101

10 X 10 TO THE INCH 48 0703  
7 X 10 INCHES  
MILLEN-ROSS CORP.



**K·E** 10 X 10 TO THE INCH 46 0703  
7 X 10 INCHES EAST IN C.L.C.  
KAUFFEL & BERGER CO.

MAXIMUM ALLOWABLE STRESS (PSI)  $\cdot 10^3$

FIGURE 5. MAXIMUM ALLOWABLE STRESS.

MS  
TEMPERATURE

SURFACE CONSTRUCTION DIVISION

### Midland-Ross Corporation

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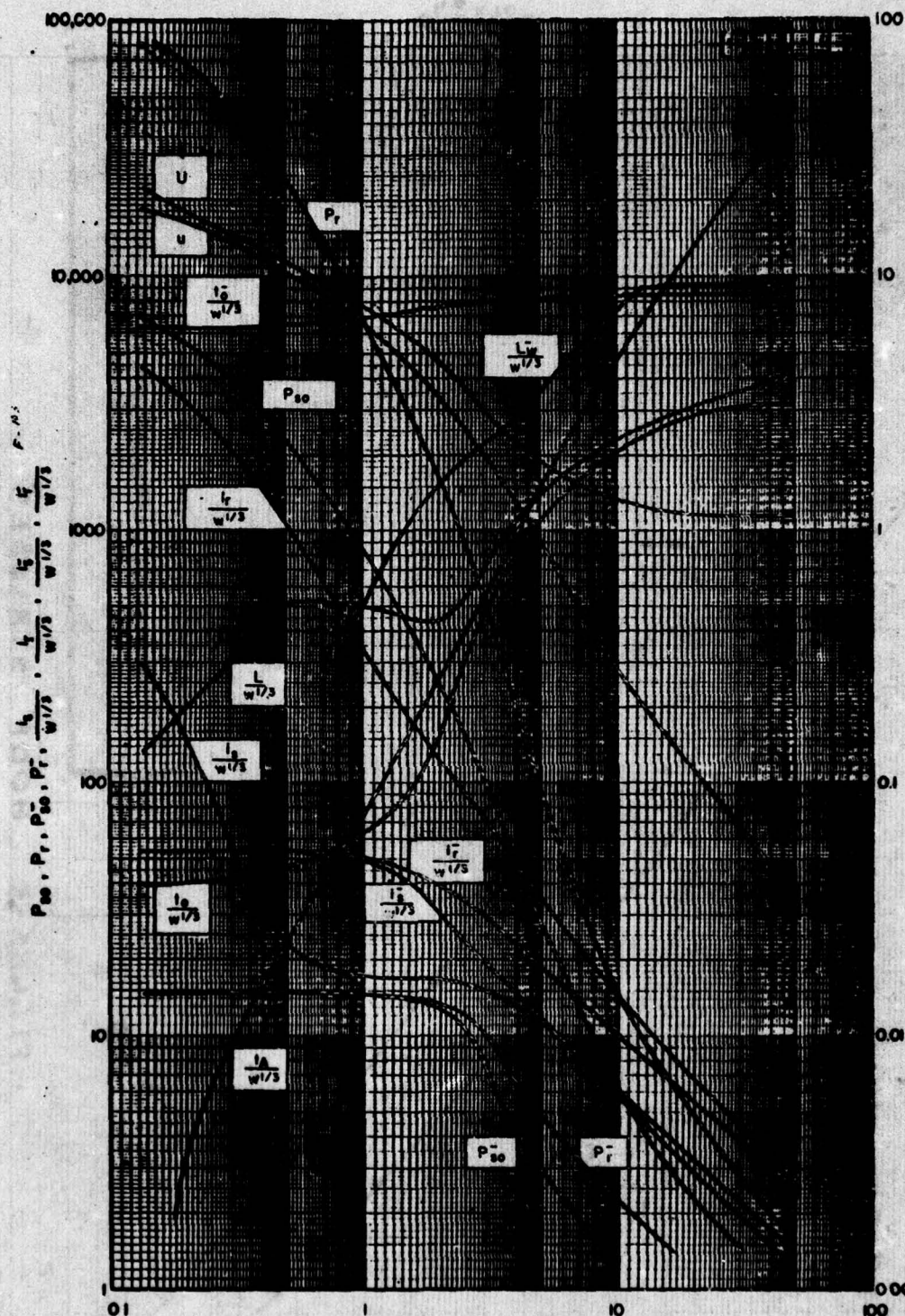


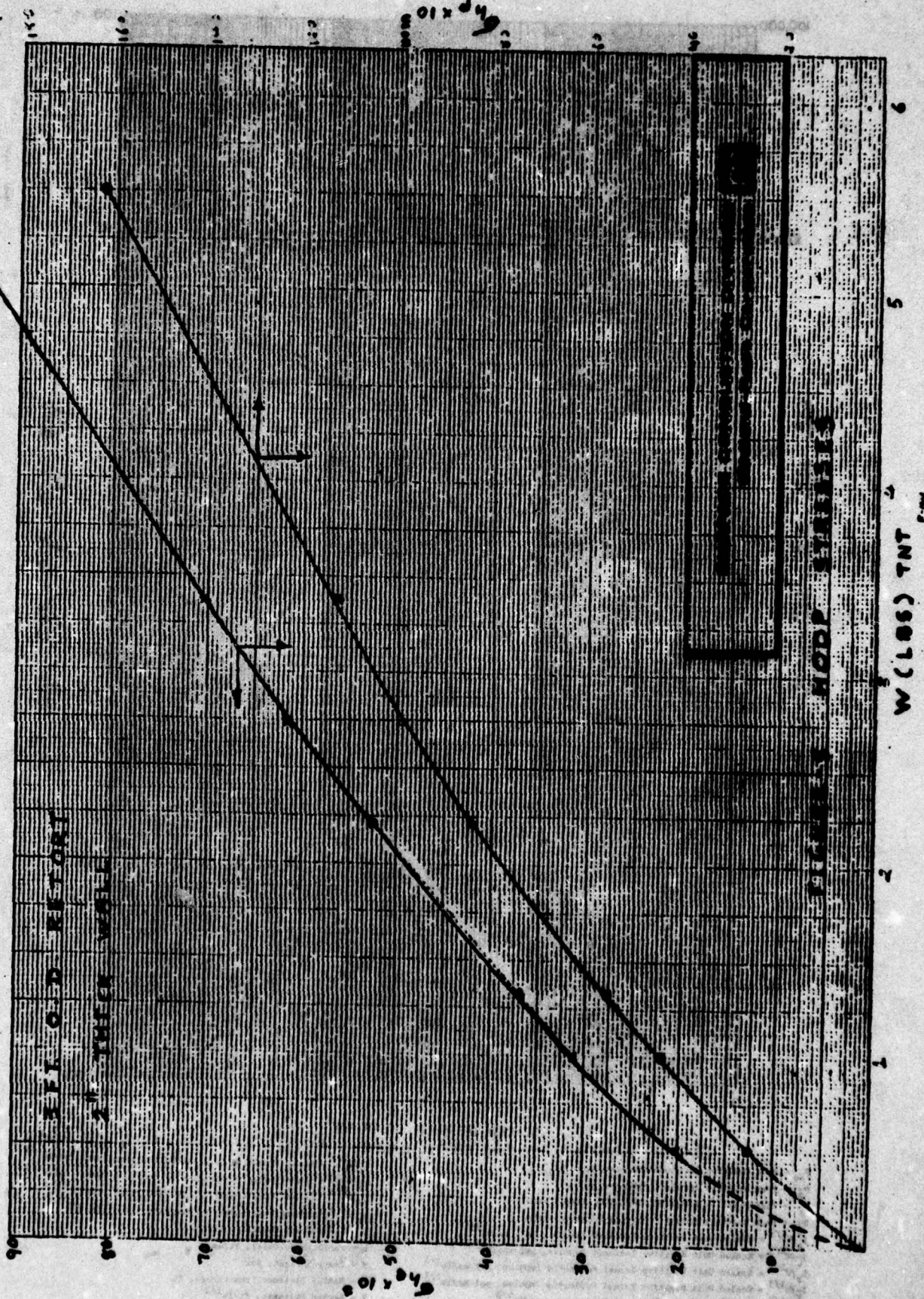
FIG. 4 SHOCK WAVE PARAMETERS FOR SPHERICAL TNT CHARGE

- $P_{00}$  = Peak Positive Incident Pressure, psi  
 $P_{00}$  = Peak Negative Incident Pressure, psi  
 $P_r$  = Peak Positive Normal Reflected Pressure, psi  
 $P_r$  = Peak Negative Normal Reflected Pressure, psi  
 $t_{00}^{1/3}$  = Scaled Unit Positive Incident Impulse, psi-ms/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Unit Negative Incident Impulse, psi-ms/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Unit Positive Normal Reflected Impulse, psi-ms/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Unit Negative Normal Reflected Impulse, psi-ms/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Time of Arrival of Blast Wave, ms/lb<sup>1/3</sup>

- $t_{00}^{1/3}$  = Scaled Positive Duration of Positive Phase, ms/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Negative Duration of Positive Phase, ms/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Wave Length of Positive Phase, ft/lb<sup>1/3</sup>  
 $t_{00}^{1/3}$  = Scaled Wave Length of Negative Phase, ft/lb<sup>1/3</sup>  
 $U$  = Shock Front Velocity, ft/ms  
 $u$  = Particle Velocity, ft/ms  
 $W$  = Charge Weight, lbs  
 $R$  = Radial Distance from Charge, ft  
 $Z$  = Scaled Distance, ft/lb<sup>1/3</sup>



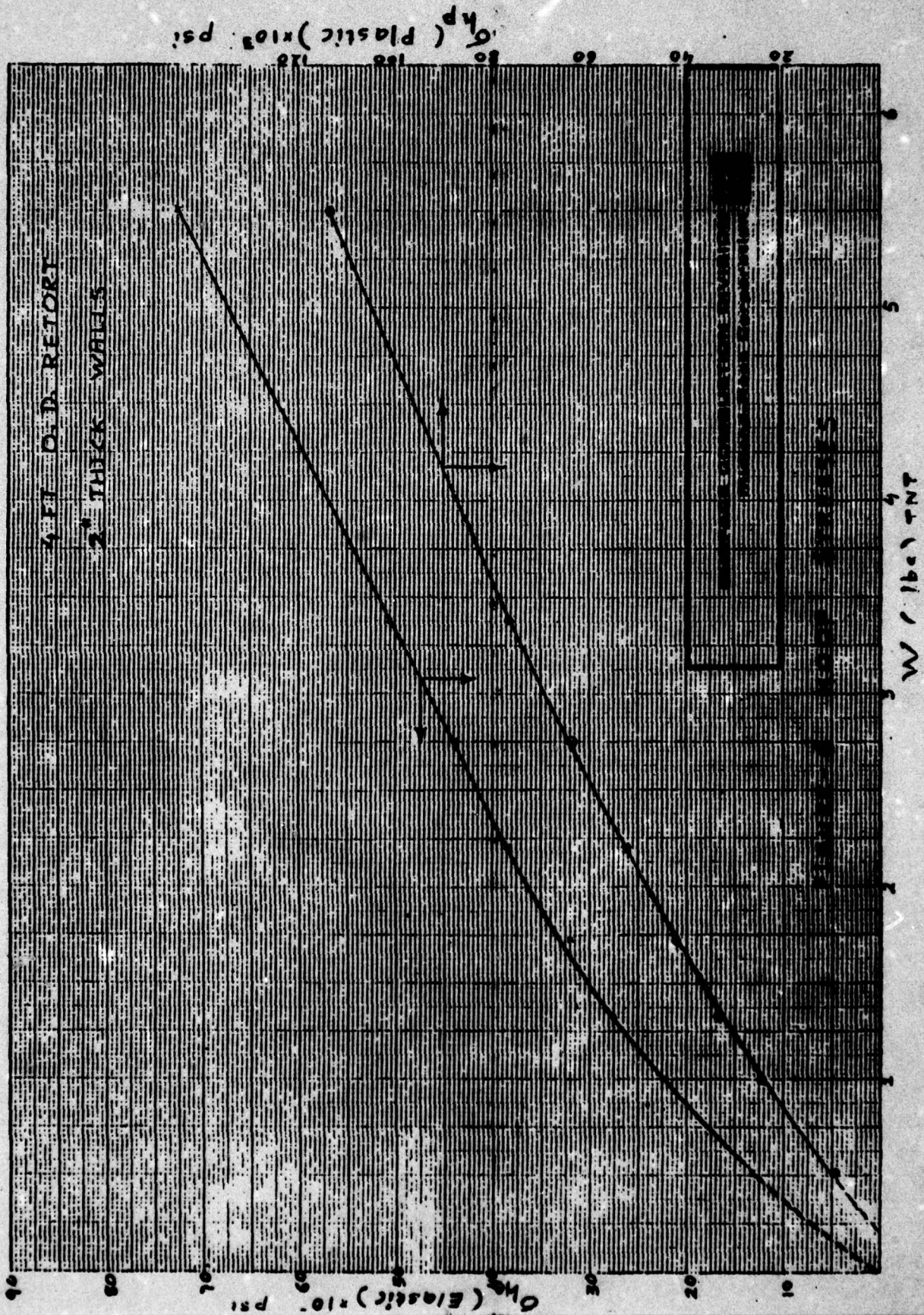
NO. 10 X 10 TO THE CENTIMETER 46 1513  
 MADE IN U.S.A.  
 KEUFFEL & ESSER CO.





F-75

10 X 10 TO THE CENTIMETER 46 1513  
H. A. 25 CO.  
REUPPEL & EDDER CO.



W / 1600 TNT



F-107

NEW YORK 30

全書共八冊

**FOR**

**DATA ITEM A 008**

100-443886-100

**Prepared by**

**MIDLAND-ROSS CORPORATION**

1. It is recommended that the existing facility be used in the existing facility unless temperatures are maintained to less than 110°F.

2. It is further recommended that the existing facility be used in the existing facility unless temperatures are maintained to less than 110°F.

3. It is further recommended that the existing facility be used in the existing facility unless temperatures are maintained to less than 110°F.

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**Distribution: SAREA-DM: (4/1)**  
**File: PX-1300**



SURFACE CORROSION

**SURFACE CORROSION**

0110-3-21-21 AAAG  
33AWNUT STRAT JATM  
0010-3-21-21 AAAG

**OBJECTIVE:**

The objective of this program was to study the corrosion rate for several materials of construction subjected to the environmental conditions approximately equivalent to those anticipated in the prototype CAMDS Deactivation Furnace System. Corrosion rates were to be determined at a temperature of 1300°F.

**SUMMARY:**

Tests were conducted in a laboratory muffle furnace at 1300°F, in simulated atmospheres of VX plus HTH, GB, mustard, and VX plus lead acetate. The most corrosive atmosphere was found to be mustard, which produced high corrosion rates in all but types HT, HK, and 310 alloys. The previously used WC-9 retort material was excessively corroded in all atmospheres at 1300°F. These tests, run under closely controlled laboratory conditions for reasonable test times greater than 40 hours provided a good comparison between the eleven alloys tested. The cast alloys performed well in all atmospheres as did type 310 stainless. Except in the case of mustard, Hastelloy C-276, Hastelloy X, Inconel 671 and Inconel 601 also performed reasonably well.

**RECOMMENDATIONS:**

1. Temperatures should be held below 1150°F in mustard gas to avoid formation of nickel sulfide where high nickel alloys are present, thereby allowing more flexibility in material selection.
2. Materials should be heated to a temperature above the operating point of the process for several hours minimum in air to preoxidize the alloy prior to introducing the corrosive materials. This will provide an additional safety factor in obtaining good material life.
3. It is recommended that Inconel 601, WC-9, and Nickel 200 not be used in the mustard processing facility unless temperatures are restricted to less than 1150°F.
4. It is further recommended that since laboratory conditions cannot be expected to exactly duplicate actual service, provision be made to install corrosion test racks in the final facility to evaluate corrosion in the various sections exposed to high temperature gases. These results can be used for better selection of replacement parts and for future furnaces.



### INTRODUCTION

The deactivation and detoxification process for the munitions containing mustard and nerve agent residue generate a corrosive atmosphere within the intended processing equipment. Since corrosion rate is an important variable in specifying material thicknesses, it is desirable to know the effect of the corrosive atmospheres generated on the corrosion of possible materials to be used in the design of Chemical Demit Equipment. The corrosion tests performed as part of the CAMDS Piloting Program were of too short duration or contained uncontrolled variables so that these tests were useful only for qualitative evaluation. Longer duration closely controlled laboratory tests were performed in the Materials Laboratory at the Surface Combustion Division of Midland-Ross Corporation.

### DESCRIPTION

Four sample sets were prepared at Surface Combustion for the corrosion rate study. Eleven different alloys were used as test samples in assembly of the sample sets. These alloy samples are listed in Table 1, along with their compositions. The alloys were selected to provide comparisons with the previous tests and test materials already selected for use in the CAMDS Deactivation System. In addition, a sample WC-9 retort was included to provide a comparison with this known material of retort construction. To avoid possible confusion with previous test results, the samples are numbered 18 through 28 to identify these samples. In the tables showing corrosion test results, the samples are designated by four digit numbers. The first two digits represent the sample number as indicated in Table 1 and the last two digits represent the test number.

Tests were conducted in an electrically heated muffle furnace with full proportioning automatic temperature control. To contain the samples and the simulated toxic gases, an alloy muffle was constructed. This muffle contained an inlet for introducing the agent simulants into the rear of the muffle, thus providing for preheating and vaporizing the simulants prior to introduction. An exhaust tube was connected to an 18% caustic solution for scrubbing the effluent gases. Separate temperature measurement means were provided for accurately determining the temperature in the vicinity of the test samples. The equipment setup is shown in Figures 1 and 2. Sample location and a photograph of a typical sample set after testing are shown in Figure 3.

Four tests were carried out at 1300°F. These were planned for 100



hour duration, but due to equipment difficulties, three of the tests were suspended after approximately 50 hours. The test conditions are listed in Table 2.

In each test, the samples were weighed and their surface area measured before testing. The samples were placed in the alloy muffle, which was then heated to 1300°F in approximately 3 hours. When the samples were at temperature as determined by the sample thermocouple, the simulant gas flow was initiated and the test time begun. At the conclusion of the test, the simulant flow was stopped and the muffle cooled to room temperature in air.

After testing, the samples were inspected for any unusual features such as type of scale, deposits, cracks or pits. The samples were then cleaned by very light sand blasting to remove all scales and deposits. After cleaning, the samples were weighed. In the case of the samples showing evidence of excessive attack, cross sections were examined metallographically.

The measurements were used to calculate a corrosion rate (R) in mils per year:

$$R = K \frac{\Delta W}{D \times A \times T}$$

where  $K = 5.34 \times 10^5$

$\Delta W$  = change in weight in grams

D = density in gms/cc

A = surface area in square inches

T = test time in hours

## RESULTS

1. Corrosion test results for the samples exposed for 44 hours in GB simulant are tabulated in Table 3.
2. Corrosion test results for the samples exposed for 50 hours in VX simulant plus HTH solution are tabulated in Table 4.
3. Corrosion test results for the samples exposed for 100 hours in mustard simulant are tabulated in Table 5.
4. Corrosion test results for the samples exposed for 50 hours in VX simulant plus lead acetate solution are tabulated in Table 6.



### DISCUSSION

The original test plan called for a test duration of 100 hours. Due to difficulties in injecting simulant and plugging problems due to condensed phases, three of the tests were run only half the proposed time duration. As corrosion rate curves are generally parabolic in nature, a higher than expected rate would be predicted by short duration tests. Since the corrosion rates were relatively low, it is believed that the times were sufficiently long to yield adequate data for conservative corrosion prediction.

In the test using GB simulant, it was possible to use known vapor pressure data to calculate a feed rate of solution, then bubble air through the simulant at a fixed flow rate to simulate gas concentrations expected in actual practice. This test was discontinued after 44 hours due to plugging of the muffle inlet and effluent tubes.

In the other tests, because it was not possible to accurately determine vapor pressures of some components, the simulants were fed dropwise into the muffle using air (nitrogen in the case of the mustard test) to propel the drops into the muffle. Since the inlet passed through to the rear of the muffle, the liquid was vaporized before actually entering the sample enclosure. Because of the low feed rate of liquid, the drops were introduced for approximately 15 seconds every 3 to 6 minutes, using timers to control the feed time. Since some of the simulants would not mix (mustard in particular), two separate liquid feed pipes were provided, controlled by the same set of timers.

All tests showed significantly different corrosion rates than the racks exposed in the pilot scale tests at the M-34 plant (RMA) and the test facility at Tooele. The differences are caused by the differing test temperatures at these locations, as well as differences in time duration.

All tests, however, indicate that the most severe corrosion conditions will be encountered in the mustard facility. In the laboratory tests, corrosion rates as high as 4200 mils/year were encountered. Materials experiencing corrosion rates in excess of 100 mils per year would be of questionable worth. In the mustard tests, the high nickel alloys experienced molten phase attack due to formation of nickel sulfide, resulting in very high rates of corrosion. In those samples having a high chromium content, no such attack was experienced, although sulfides were found in the structure by metallographic examination. Since nickel and sulfur form an eutectic



melting at 1180°F the temperature would need to be held to less than this value to yield satisfactory life with nickel base alloys such as Inconel 601.

No pitting or cracking was found in any of the tests. Type 304 stainless showed intergranular sensitization which would produce shorter than predicted life due to intergranular corrosion, so that this material would not be recommended.

In all tests, the WC-9 material previously used as for retort construction experienced severe corrosion.

#### CONCLUSIONS

In these tests, VX plus HTH and VX plus lead were found to be the least corrosive agents, followed by GB and then mustard. For all tests, the cast alloys and several wrought alloys performed well. Listed below are two sets of alloys which could be used in each condition to a maximum temperature of 1300°F.

##### 1. VX + HTH

- a. Alloys N1200, HT HK, HF, 310, Hastelloy X: corrosion rates less than 30 mils/year acceptable.
- b. Alloys 601, Hastelloy C-276, 671: corrosion rates less than 70 mils/year to be used with caution.

##### 2. GB

- a. Alloys Hastelloy X, C-276, 310, 601, HT, HK, and 671: corrosion rates less than 60 mils/year acceptable.
- b. All other materials tested were unacceptable.

##### 3. MUSTARD

- a. Alloys HT, HK, 310: corrosion rates less than 70 mils/year acceptable.
- b. Alloys HF, Hastelloy X, C-276, 671: corrosion rates less than 200 mils/year to be used with caution.

##### 4. VX + Pb

- a. Alloys HK, HT, N1200, HF, 671, 310, Hastelloy C-276: corrosion rates less than 30 mils/year acceptable.
- b. Alloys 601, Hastelloy X: corrosion rates less than 40 mils/year acceptable.



FOIA b 7 - D

No.	Altitude	Temperature	Wind	Direction	Time	Remarks
1	1000	60	10	SE	10:00	Clear
2	1000	60	10	SE	10:10	Clear
3	1000	60	10	SE	10:20	Clear
4	1000	60	10	SE	10:30	Clear
5	1000	60	10	SE	10:40	Clear
6	1000	60	10	SE	10:50	Clear
7	1000	60	10	SE	11:00	Clear
8	1000	60	10	SE	11:10	Clear
9	1000	60	10	SE	11:20	Clear
10	1000	60	10	SE	11:30	Clear
11	1000	60	10	SE	11:40	Clear
12	1000	60	10	SE	11:50	Clear
13	1000	60	10	SE	12:00	Clear
14	1000	60	10	SE	12:10	Clear
15	1000	60	10	SE	12:20	Clear
16	1000	60	10	SE	12:30	Clear
17	1000	60	10	SE	12:40	Clear
18	1000	60	10	SE	12:50	Clear
19	1000	60	10	SE	13:00	Clear
20	1000	60	10	SE	13:10	Clear
21	1000	60	10	SE	13:20	Clear
22	1000	60	10	SE	13:30	Clear
23	1000	60	10	SE	13:40	Clear
24	1000	60	10	SE	13:50	Clear
25	1000	60	10	SE	14:00	Clear
26	1000	60	10	SE	14:10	Clear
27	1000	60	10	SE	14:20	Clear
28	1000	60	10	SE	14:30	Clear
29	1000	60	10	SE	14:40	Clear
30	1000	60	10	SE	14:50	Clear
31	1000	60	10	SE	15:00	Clear
32	1000	60	10	SE	15:10	Clear
33	1000	60	10	SE	15:20	Clear
34	1000	60	10	SE	15:30	Clear
35	1000	60	10	SE	15:40	Clear
36	1000	60	10	SE	15:50	Clear
37	1000	60	10	SE	16:00	Clear
38	1000	60	10	SE	16:10	Clear
39	1000	60	10	SE	16:20	Clear
40	1000	60	10	SE	16:30	Clear
41	1000	60	10	SE	16:40	Clear
42	1000	60	10	SE	16:50	Clear
43	1000	60	10	SE	17:00	Clear
44	1000	60	10	SE	17:10	Clear
45	1000	60	10	SE	17:20	Clear
46	1000	60	10	SE	17:30	Clear
47	1000	60	10	SE	17:40	Clear
48	1000	60	10	SE	17:50	Clear
49	1000	60	10	SE	18:00	Clear
50	1000	60	10	SE	18:10	Clear
51	1000	60	10	SE	18:20	Clear
52	1000	60	10	SE	18:30	Clear
53	1000	60	10	SE	18:40	Clear
54	1000	60	10	SE	18:50	Clear
55	1000	60	10	SE	19:00	Clear
56	1000	60	10	SE	19:10	Clear
57	1000	60	10	SE	19:20	Clear
58	1000	60	10	SE	19:30	Clear
59	1000	60	10	SE	19:40	Clear
60	1000	60	10	SE	19:50	Clear
61	1000	60	10	SE	20:00	Clear
62						

**Notes:** Composition of Unit E 170, Band 8 are unusual; all others are normal - include occasionally added elements only.



TABLE 1 - COMPOSITION OF SAMPLES

No.	Sample Alloy	Weight Per cent						
		Cr	Ni	W	Co	Mo	Fe	Other
18	HT	17	35				Bal	
19	HK-40	26	20				Bal	
20	HF	20	10				Bal	
21	N1200		100					
22	In.671	50	50					
23	310	25	20				Bal	
24	304	18	9				Bal	
25	WC-9	2 1/4				1	Bal	
26	HastC-276	16	Bal	3.4	2.4	15	6	.19V, 0.006C
27	Hast X	22	Bal	.7	2	8.8	18.5	0.06C
28	In.601	23	61				14	1.4Al, 0.25Cu

Note: Composition of Hast C-276, Hast X are actual; all others are nominal - include intentionally added elements only.



TABLE 2 - TEST CONDITIONS

Test Designation	Simulant	Materials (Feed rate)	Gas Flow	Test Time
9	GB	Trimethyl Phosphite (0.93 lb/100 hr [held 32°F]) Benzotrifluoride (0.47 lb/100 hr [held 86°F])	1 cfh (air)	44 hours
10	VX + HTH	Bis (2-Ethyl Hexyl) Hydrogen Phosphite (126 ml/100 hr) HTH (10% solution) (114 ml/100 hrs)	1 cfh (air)	50 hours
11	Mustard	Thiodiglycol (2.7 ml/hr) Methylene Chloride (1.7 ml/hr)	0.1 cfh (Nitrogen)	100 hours
12	VX + Lead Acetate	Bis (126 ml/100 hrs) Lead Acetate (10% solution) (500 ml/100 hrs)	1 cfh	50 hours

U = length in inches  
W = width in inches  
t = thickness in inches



**SURFACE CORROSION**

**TABLE 3 - BENCH SCALE CORROSION TEST RESULTS**  
**GB SIMULANT 44 HOURS AT 1300°F**

Sample	Wt. gm	L	W	t	Surface Area	Density	Wt. Change	Rate: mils/yr
1809	112.429	1.79	1.271	.398	6.987	7.577	0.173	39.75
1909	114.969	1.804	1.271	.406	7.083	7.537	0.252	57.25
2009	115.757	1.839	1.274	.400	7.172	7.543	0.296	66.43
2109	36.967	1.792	1.334	.109	5.459	8.697	6.571	1679.58
2209	39.612	1.794	1.337	.130	5.611	7.752	0.212	59.20
2309	18.438	1.733	1.332	.063	5.000	7.742	0.052	16.43
2409	18.226	1.729	1.336	.062	4.999	7.768	0.172	53.82
2509	90.566	1.734	1.271	.330	6.391	7.599	2.720	679.68
2609	43.962	1.787	1.324	.130	5.541	8.722	0.107	26.95
2709	36.217	1.787	1.293	.117	5.342	8.175	0.037	10.17
2809	33.611	1.716	1.271	.120	5.078	7.839	0.082	25.03

L = Length in inches  
W = Width in inches  
t = thickness in inches

Surface Area - square inches  
Density - grams/cc



**TABLE 4 - BENCH SCALE CORROSION TEST RESULTS**  
**VX SIMULANT + H<sub>2</sub>O 50 HOURS AT 1300°F**

Sample	Wt. gm	L	W	t	Surface Area	Density	Wt. Change	Rate: mils/yr
1810	119.352	1.843	1.285	.405	7.270	7.594	0.082	15.90
1910	107.953	1.682	1.268	.411	6.690	7.515	0.091	19.37
2010	97.568	1.572	1.275	.394	6.252	7.540	0.092	20.87
2110	37.175	1.795	1.344	.109	5.509	8.627	0.060	13.37
2210	39.766	1.789	1.345	.107	5.483	9.425	0.259	53.61
2310	18.481	1.725	1.330	.063	4.973	7.803	0.077	21.08
2410	17.723	1.728	1.296	.063	4.860	7.666	0.254	72.84
2510	62.68	1.745	1.300	.230	5.938	7.331	5.549	1361.48
2610	43.883	1.787	1.329	.130	5.560	8.674	0.160	35.37
2710	35.917	1.803	1.290	.118	5.382	7.986	0.093	23.09
2810	35.322	1.8	1.287	.119	5.368	7.819	0.135	34.40

L = Length in inches      Density - grams/cc  
W = Width in inches      Surface Area - square inches  
t = thickness in inches



**TABLE 5 - BENCH SCALE CORROSION TEST RESULTS**  
**MUSTARD SIMULANT 100 HOURS AT 1300°F**

Sample	Wt. gm	L	W	t	Surface Area	Density	Wt. Change	Rate: mils/yr
1811	97.395	1.55	1.273	.392	6.16	7.684	0.188	21.2
1911	116.688	1.842	1.268	.403	7.178	7.565	0.577	56.75
2011	105.177	1.668	1.277	.400	6.614	7.536	0.743	79.57
2111	37.438	1.793	1.352	.110	5.54	8.568	37.438	4211.81
2211	40.761	1.79	1.336	.134	5.621	7.762	1.474	180.37
2311	18.585	1.74	1.329	.063	5.012	7.785	0.505	69.18
2411	17.94	1.722	1.322	.062	4.93	7.756	0.308	42.97
2511	64.632	1.749	1.27	.245	5.922	7.248	7.155	890.28
2611	44.265	1.791	1.327	.13	5.564	8.743	1.421	55.99
2711	36.231	1.789	1.292	.117	5.344	8.176	1.093	133.623
2811	32.673	1.722	1.235	.12	4.963	7.813	3.087	425.077

L = Length in inches  
W = Width in inches  
t = thickness in inches

Surface Area = square inches  
Density = grams/cc



**SURFACE COMBUSTION**

**TABLE 6 - BENCH SCALE CORROSION TEST RESULTS  
VX SIMULANT + LEAD ACETATE 50 HOURS AT 1300°F**

<u>Sample</u>	<u>Wt. gm</u>	<u>L</u>	<u>W</u>	<u>t</u>	<u>Surface Area</u>	<u>Density</u>	<u>Wt. Change</u>	<u>Rate: mils/yr</u>
1812	107.962	1.691	1.283	.398	6.706	7.63	0.053	5.56
1912	94.244	1.447	1.299	.414	6.033	7.391	0.034	4.05
2012	91.78	1.464	1.276	.402	5.939	7.458	0.093	11.21
2112	37.015	1.793	1.338	.109	5.481	8.638	0.046	5.18
2212	39.971	1.794	1.346	.131	5.652	7.711	0.112	13.74
2312	18.486	1.727	1.336	.064	5.007	7.64	0.112	15.60
2412	18.048	1.747	1.308	.062	4.949	7.774	0.252	34.94
2512	87.274	1.736	1.273	.317	6.328	7.602	9.586	1064.18
2612	44.444	1.789	1.334	.131	5.591	8.675	0.146	16.12
2712	35.92	1.79	1.287	.117	5.327	8.132	0.289	35.61
2812	33.296	1.699	1.267	.119	5.011	7.932	0.236	31.72

L = Length in inches      Surface Area - square inches  
W = Width in inches      Density - grams/cc  
t = thickness in inches

F-119



# SURFACE COMBUSTION

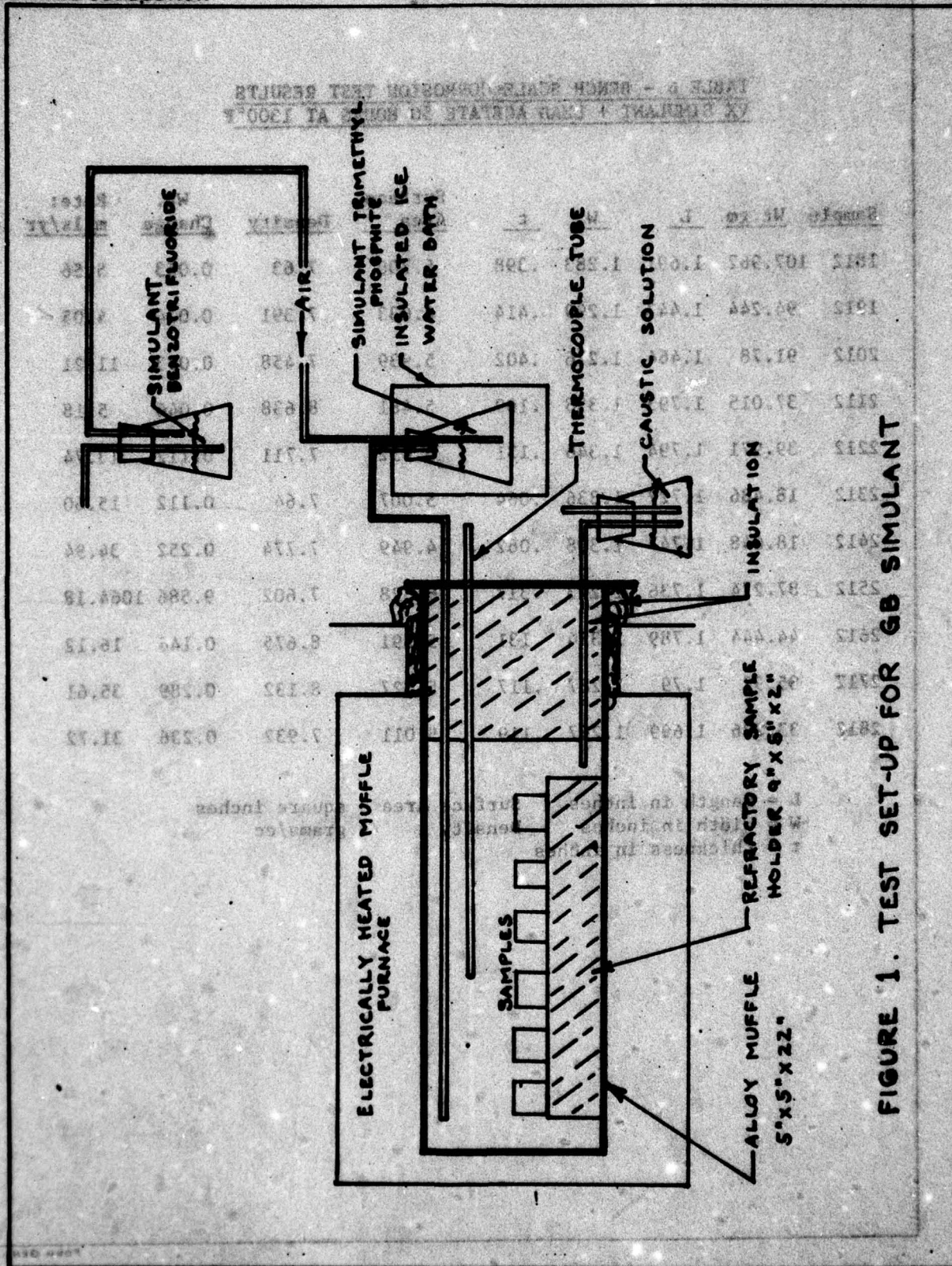
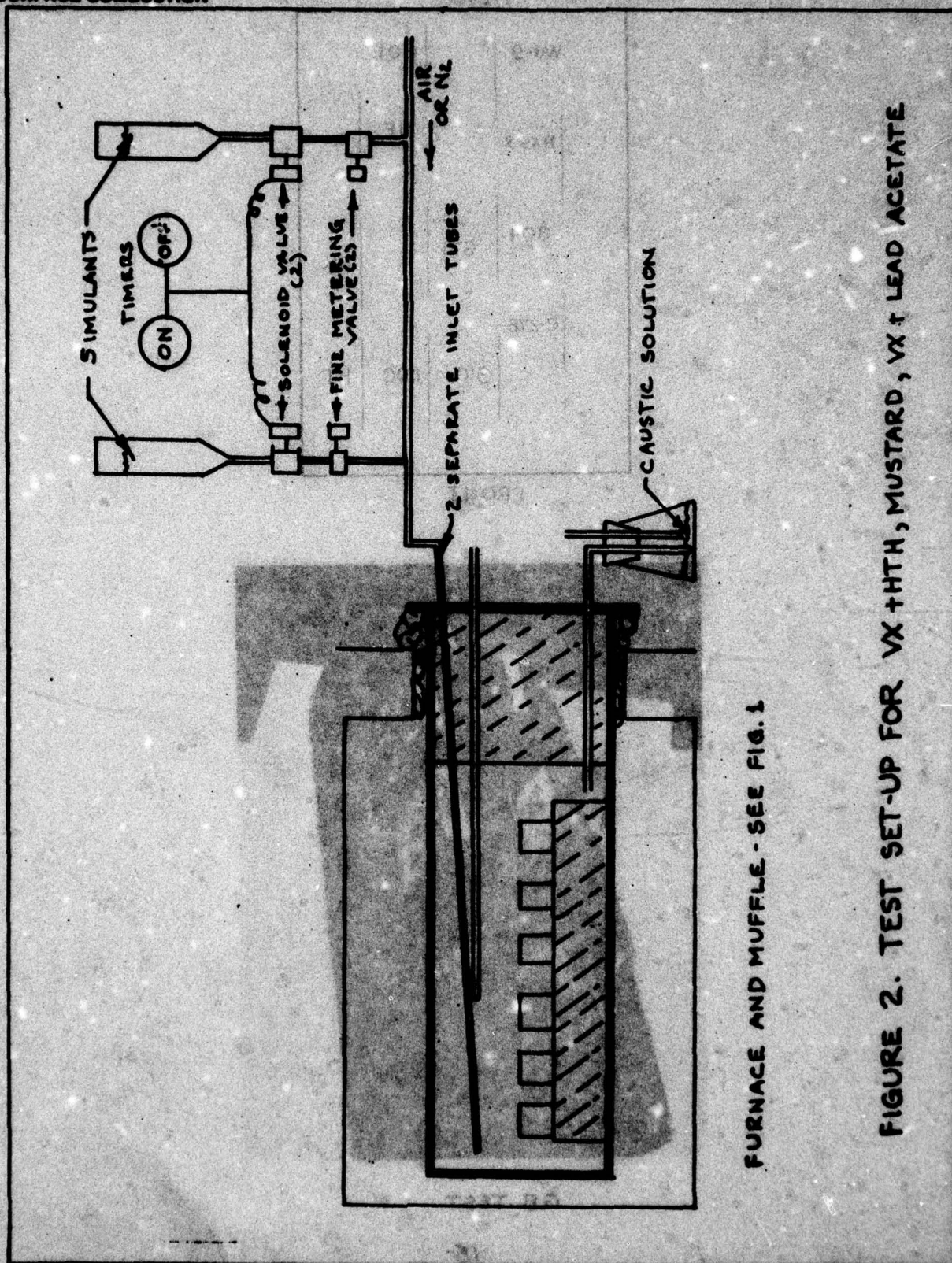


FIGURE 1. TEST SET-UP FOR GB SIMULANT



SURFACE COMBUSTION



FURNACE AND MUFFLE - SEE FIG. 1

FIGURE 2. TEST SET-UP FOR VX + HTH, MUSTARD, VX + LEAD ACETATE



STAT3A QMJ XV, STAT3B, NTH+ XV 907 QU T3E T23T . S 391014



F122



Slagging Afterburner  
DAAG15-75-C-0084

**Slagging Afterburner**  
**DAAG15-75-C-0084**

**INTRODUCTION**

In inventory of M3 rockets and shipping tubes is stored at the facility near report, fossils, green. The rockets and shipping tubes must be deactivated for safe disposal. The shipping tubes are constructed of fiberglass and bonding resins. Bonding resins decompose in the deactivation furnace leaving a fibrous glass wool. Fibrous glass wool particulates enter the line

**PILOT TEST**

**FOR**

**SLAGGING AFTERBURNER**

**PK-1298**

to determine the effect of fibrous glass wool particulates with respect to loading of the afterburner firing system and slagging of the recovery walls. The fibrous glass wool enters at temperature in excess of 1800°F. that would be detrimental to the recovery, burners and safety devices.

The concept of this report describes the test program, equipment used to perform the tests and results of the tests. A pilot investigation, 1/8 the actual size, was conducted consisting of an afterburner 1'-0" inside diameter by 11'-0" high. The tests were performed using this facility, as

**PREPARED BY**

**SURFACE COMBUSTION DIVISION**

**MIDLAND-ROSS CORPORATION**

**June 25, 1975**

F-123



## I. INTRODUCTION:

An inventory of M55 rockets and shipping tubes is stored at the Tooele Army Depot; Tooele, Utah. The rockets and shipping tubes must be deactivated for safe disposal. The shipping tubes are constructed of fiberglass and bonding resins. Bonding resins decompose in the deactivation furnaces leaving a fibrous glass wool. Fibrous glass wool particulates enter the flue gas stream and are carried through the afterburner and other air pollution abatement equipment. A test program was undertaken to determine the affect of fibrous wool particulates with respect to fouling of the afterburner firing system and slagging of the refractory walls. The fibrous wool softens at temperatures in excess of 1600°F. that could be detrimental to the refractory, burners and safety devices.

The content of this report describes the test program, equipment used to perform the tests and results of the tests. A pilot installation, 1/6 the actual size, was constructed consisting of an afterburner 2'-0" inside diameter by 12'-0" high effective. The tests were performed using this facility, an existing rotary kiln and fibrous wool supplied by the Department of the Army.



**II. TEST OBJECTIVES:**

The tests were conducted to demonstrate the feasibility and reliability of the afterburner concept with respect to the following objectives:

- a. To evaluate the manner and intensity of slag formation on the refractory lining at various temperatures and particulate flow rates.
- b. To identify the physical characteristics of the slag with respect pourability, accumulation and penetration.
- c. To identify the chemical characteristics of the slag.
- d. To evaluate the corrosion and erosion resistance of selected refractories under actual slagging conditions.



Slagging Afterburner  
DAAA15-75-C-0084**III. TEST FACILITIES:**

The tests were conducted in facilities constructed specifically for the intended objectives and existing equipment located in the Research and Development Laboratory of Surface Combustion Division; Midland-Ross Corporation; Toledo, Ohio. The pilot afterburner installation is shown on drawings 148903-D, 148908-D, 148911-D and photographs dated 4/16/75. The afterburner is heated directly by two Surface 500,000 B.t.u./hr. throat mix burners mounted to fire tangentially into the top mounted burner section. Fuel used for these burners was propane. The rotary kiln excess air burner rated 1 mm B.t.u./hr. used natural gas. An exhaust system is located at the bottom of the afterburner for removal of flue gas from both the rotary kiln and afterburner to atmosphere.

An automatic temperature and safety control panel, attached to the afterburner supporting framework, provides accurate control for all items involved. Temperature sensing devices are type K thermocouples inside alloy protection tubes.



## IV. TEST PREPARATION:

Prior to starting the pilot test, several attempts were made to pulverize the fibrous matted wool unsuccessfully here in our laboratory. Samples were inserted into a laboratory furnace to determine actual melting point of the wool. This value was determined as being 1600 to 1650°F. These tests dictated that feeding fibrous particulates into the afterburner using a particulate feeder was not practical.

The problem was resolved by conducting further tests in an existing Surface Combustion rotary kiln heated by an excess air burner. During this phase of the test only visual indication of particulate flow was used to verify the fact that fiberglass was flowing along with flue gas into the afterburner. Sample ports were installed in both the inlet and outlet ducts of the afterburner. STW Testing, Incorporated was assigned the task of measuring flow rates.

A final check of the system verified the temperature capabilities of both the rotary kiln and the afterburner that were initially established. Temperature measurement was accomplished using chromel-alumel thermocouples inserted into alloy protection tubes. The kiln was monitored at its inlet and outlet, the afterburner at its inlet and two locations within the 12'-0" effective height, one near the top, one at the bottom.

The fiberglass, supplied by the Department of the Army, was loaded into the rotary kiln, one half drum per charge or approximately 60 lbs.



Slagging Afterburner  
DAAA15-75-C-0084

V. TEST DESCRIPTION:

After all test preparations and initial checkout were completed, the rotary kiln and pilot afterburner were ignited in preparation for particulate flow sampling. The events at different periods during the test are described as follows.

Date	Event
3/10/75	Complete system started. Kiln set to control at 1300°F., afterburner set to control at 1600°F. STW Testing, Inc. set-up for afterburner inlet sampling. Air flow to afterburner inlet; 14,000 s.c.f.h. at 900°F. Kiln not rotating.
3/11/75	STW Testing, Inc. obtained second sample, same conditions as 3/10/75 except that the kiln was rotating.
3/12/75	No samples obtained. Pilot test running at same conditions as 3/11/75.
3/13/75	Two samples obtained, one at afterburner inlet 14,000 s.c.f.h. air at 900°F. and one at afterburner outlet 20,000 s.c.f.h. air at 900°F. Kiln and afterburner temperatures 1300°F. and 1600°F. respectively.
3/14/75	Completed sampling of particulate flow rates. Three samples taken by STW Testing, Inc., two at afterburner inlet, one at outlet. Flow rates into afterburner were 20,000 and 10,000 s.c.f.h. Kiln and afterburner temperature same as 3/13/75.



DAAG15-75-C-0084

Slagging Afterburner  
DAAG15-75-C-0084

Date	Event
3/15 & 3/16/75	Weekend shutdown.
3/17 through 3/31/75 inclusive	Resumed operation for completion of tests 1 and 2, slag growth-flowability and accelerated slagging tests.
4/1 through 5/2/75	Accelerated refractory life cycle test, 120 cycles completed.

Throughout the test period, the following data was documented as delineated in the attached table.

- Kiln inlet temperature, °F.
- Kiln outlet temperature, °F.
- Kiln air flow rate, s.c.f.m.
- Afterburner inlet temperature, °F.
- Afterburner temperature, °F.
- Afterburner fuel flow rate, s.c.f.h.
- Afterburner air flow rate, s.c.f.m.
- Afterburner exhaust temperature, °F.
- Slag formation rates, lbs.
- Slag physical and chemical properties
- Afterburner casing temperatures
- Isokinetic sampling of afterburner inlet and outlet.



Slagging Afterburner  
DAAA15-75-C-0084

# VI. TEST RESULTS:

The following items highlight the test results.

- a. Slagging of the afterburner interior refractory lining did occur most predominately in the top uppermost burner section.
- b. Slag did accumulate in the afterburner bottom collector.
- c. Fouling of the burners did not occur.
- d. Fouling of the burner safety ultra-violet flame detectors did not occur.
- e. Afterburner casing temperatures were not affected by slag accumulation on interior walls.
- f. Accelerated refractory life cycle tests resulted in severe erosion of the insulating firebrick but not of the more dense refractories. Proper selection of refractory is most important.
- g. Fiberglass particulates did pass through the afterburner as indicated by STW Testing of the exhaust stack.



## VII. DISCUSSION AND CONCLUSIONS:

The test results definitely show that the afterburner concept is feasible with respect to slagging of the fibrous particulates, not all of the fibrous particulates are retained in the afterburner and selection of the inner course of refractory insulation is critical.

The 1/6 scale prototype oriented to fire downward with the hot track burner design does maintain the uniform temperature required to effect slagging in a vertically downward direction. The photographs, attached as part of this report, illustrate this quite clearly. The full size design will operate in a similar manner.

Flow rates of the fibrous particulates used in the pilot test are related as being much higher than those expected in the final installation as indicated by tests at Tooele and the samples taken by STW Testing of the prototype. This accounts for the severe slagging during pilot testing. Regardless of this, the pilot tests definitely did dictate exactly which type of the six materials used for the inner refractory lining is suitable for the process with respect to slagging, thermal shock, temperature and corrosive attack. These materials were 3000°F. insulating firebrick in the hot track burner section, 2300°F., 2600°F., 2800°F insulating firebrick, Super Duty firebrick, 60 and 90% alumina refractory for the sections immediately beneath the burner section. Examination of these refractories clearly



Slagging Afterburner  
DAAA15-75-C-0084

VII. DISCUSSION AND CONCLUSIONS

illustrates that all but the 60% and 90% alumina refractories were severely damaged by slag accumulation, corrosive attack and thermal shock. Photographs of the six refractories illustrate this phenomena.

Operating temperatures of the afterburner, thermocouple location and protection tube material, afterburner inlet temperature and full input used for the pilot test verify the data specified for the final design.

Slagging in a vertically downward direction. The photographs, attached as part of this report, illustrate this point clearly. The full size design will operate in a similar manner.

Flow traces of the fibrous particulates used in the pilot test are related as being much higher than those expected in the final installation as indicated by tests on foams and the samples taken by SW testing of the prototype. This accounts for the severe slagging during pilot testing. Regardless of this, the pilot tests definitely had shown exactly which type of the six materials used for the inner refractory lining is suitable for the process with respect to slagging, thermal shock, temperature and corrosive attack. These materials were 3000°F, 3500°F, 3800°F, 4000°F, 4200°F, 4500°F, 4800°F, 5000°F, 5200°F, 5500°F, 5800°F, 6000°F, 6200°F, 6500°F, 6800°F, 7000°F, 7200°F, 7500°F, 7800°F, 8000°F, 8200°F, 8500°F, 8800°F, 9000°F, 9200°F, 9500°F, 9800°F, 10000°F. The 60% and 90% alumina refractory for the section immediately beneath the burner section. Examination of these refractories clearly



## VIII. RECOMMENDATIONS:

From the results obtained and analysis of the pilot test we recommend the following:

- a. The final afterburner design should have an inner course of refractory insulation that has minimum porosity, 13 to 16% or less, excellent resistance to corrosive attack and excellent thermal shock resistance all of which were demonstrated by the Greenal 90. This refractory should be used for all sections including the burner section.
- b. The mortar should compliment the refractory such as Greenset 90.
- c. The intermediate and outermost courses of insulation should be 2000°F. insulating firebrick and vermiculite block insulation respectively. Neither of these were affected by slagging or thermal shock testing.
- d. Thermocouple protection tubes should be inconel alloy, or equivalent.
- e. The slag collector should have an easily removable access port for slag removal. The slag deposited in the collector of the prototype was not in a molten state and did not adhere to the refractory as suspected.
- f. A scrubber should definitely be employed in the exhaust of the afterburner to remove the particulates that are not contained in the afterburner.



**SURFACE COMBUSTION**

DAAG15-73-C-0084

Blowing Afterburner  
DAAG15-73-C-0084

From the results obtained and analysis of the data it was recommended  
g. The top uppermost afterburner inlet should be insulated to  
prevent damage from overheating as experienced in the prototype.

- a. The final afterburner design should have an inner course of refractory insulation that has minimum porosity, is in 161 or less, excellent resistance to corrosive attack and excellent thermal shock resistance all of which were demonstrated by the General 90. This refractory should be used for all sections including the burner section.
- b. The burner should completely enclose the refractory such as General 90.
- c. The intermediate and outermost courses of insulation should be 300°F. insulating fiberbrick and vermiculite block insulation respectively. Halfway of these were affected by slagging or thermal shock cracking.
- d. Thermocouple protection tubes should be inconel alloy, or equivalent.
- e. The slag collector should have an easily removable access port for slag removal. The slag deposited in the collector of the prototype was not in a molten state and did not adhere to the refractory as suspected.
- f. A snubber should definitely be employed in the exhaust of the afterburner to remove the particulates that are not contained in the afterburner.







# CROBAUGH LABORATORIES

## Report of Spectrographic Examination

TO: Surface Combustion Division

Date Reported 6-14-70  
Lab. No. E 5175  
Date Received 6-12-70  
Material DeKrom  
Marked L 1548  
P.O. # D 92532  
Letter dated 6-11-70

Attn: \_\_\_\_\_

SAMPLE NO.	<u>X1173</u>				
SPEC. NO.					
Aluminum	<u>5</u>				
Antimony	<u>ND</u>				
Arsenic	<u>ND</u>				
Barium	<u>0.005</u>				
Beryllium	<u>ND</u>				
Bismuth	<u>ND</u>				
Boron	<u>1</u>				
Cadmium	<u>ND</u>				
Calcium	<u>10</u>				
Cerium					
Chromium	<u>0.02</u>				
Cobalt	<u>0.002</u>				
Copper	<u>0.007</u>				
Fluorine					
Gallium					
Germanium					
Gold					
Hafnium					
Indium					
Iron	<u>0.2</u>				
Lead	<u>0.01</u>				
Lithium					
Magnesium	<u>1</u>				
Manganese	<u>0.005</u>				
Mercury					

SAMPLE NO.					
SPEC. NO.					
Molybdenum	<u>ND</u>				
Nickel	<u>0.005</u>				
Niobium					
Phosphorus					
Platinum					
Potassium	<u>0.1</u>				
Silicon	<u>ND</u>				
Silver	<u>ND</u>				
Sodium	<u>3</u>				
Strontium	<u>0.01</u>				
Tantalum					
Tellurium					
Tin	<u>ND</u>				
Titanium	<u>0.2</u>				
Tungsten					
Uranium					
Vanadium	<u>0.008</u>				
Zinc	<u>0.05</u>				
Zirconium	<u>0.08</u>				

ND — Not Detected.  
Values are semiquantitative estimations as percent  
in the samples as received.

*[Signature]*



SAFETY PRECAUTIONS

Shipping Address  
DAAG15-73-C-0004

Shipping Address  
DAAG15-73-C-0004

### Data Charts

Taken During The Silver Tests

(The raw data charts have been deleted from this printing.  
A copy of this material is available on request to the Project  
Manager for Chemical Demilitarization and Installation Restoration,  
DSCPA-200-12, Aberdeen Proving Ground, MD 21010.)  
(.01012 UM, 20007)



Slugging Afterburner  
DAAA15-75-C-0004

Slugging Afterburner  
DAAA15-75-C-0004

Photographs  
Taken During The Pilot Tests

F.132

(The non-reproducible photographs have been deleted from this printing. A copy of this material is available on request to the Project Manager for Chemical Reutilization and Installation Restoration, DDCPH-DDD-TM, Aberdeen Proving Ground, MD 21010.)



revised 11/17/75  
8890-C-29-21-441Slagging Afterburner  
DAAA15-75-C-8084

## PHOTOGRAPH DESCRIPTIONS

Date	Description
3/4/75	Interior view of afterburner looking from top to bottom. The photographs illustrate most specifically slagging of the top burner section. An extension cord light and excess temperature control thermocouple are also visible.
3/26/75	Slag accumulation in bottom receptacle and slag removed from afterburner resting on floor.
3/27/75	Interior view of afterburner looking from top to bottom.
3/29/75	Interior view of afterburner looking from bottom to top, slag receptacle removed.
4/14/75	Interior view of afterburner looking from top to bottom and refractory thermocouple protection tubes used initially, later replaced later by alloy tubes.
6/9/75	Photographs of the six different refractories used for the inner lining of the afterburner. They show accumulation of slag and deterioration of the unsuitable types.



Slagging Afterburner  
 DAAAL5-75-C-0004

Slagging Afterburner  
 DAAAL5-75-C-0004

PHOTOGRAPH DESCRIPTIONS

DATE	DESCRIPTION
3/15/75	Interior view of afterburner looking from top to bottom. The photographs illustrate most essentially slugging of the top burner section. In extension cold light and excess temperature control thermocouples are also visible.
3/15/75	Slag accumulation in bottom receptacle and slag removed from afterburner resting on floor.
3/15/75	Interior view of afterburner looking from top to bottom.
3/15/75	Interior view of afterburner looking from bottom to top, slag receptacle removed.
3/15/75	Interior view of afterburner looking from top to bottom and refractory thermocouple protection tubes used initially, later replaced later by alloy tubes.
3/15/75	Photographs of the six different refractorian used for the inner lining of the afterburner. They show accumulation of slag and deterioration at the unsuitable types.



STW

STW TESTING UNIT (P.O. BOX 24212) DENVER, COLO. 80224

April 18, 1975

Commander  
Edgewood Arsenal  
Attn: SAREM-EM (Alan Osgood)  
Aberdeen Proving Grounds, Maryland 21010

Subject: CAMDS Desc. Furnace Emission Testing

Gentlemen:

Attached are five copies of the report on the series of tests which were performed to determine the fiberglass concentrations in the ducts at the inlet and outlet of the afterburner located at the Surface Combustion, Division of Midland-Ross plant in Toledo, Ohio.

This test report may be added to the report folder containing the Phosphorus Determination results. We are glad to be of continued service to you.

Sincerely,  
Dennis J. Weder  
Dennis G. Weder  
Vice President



# SIW

## **SURFACE COMBUSTION AFTERBURNER**

### **FIBERGLASS REMOVAL EFFICIENCIES**

The purpose of this series of tests was to determine the fiberglass concentrations in the ducts at the inlet and outlet of the afterburner located at the Surface Combustion, Division of Midland-Ross plant in Toledo, Ohio. Testing was performed between March 10 and March 14, 1975.

A rotary drum was loaded with burned fiberglass which had been shipped from the CAMDS site at the Tooele Army Depot. The fiberglass was the remains of the M51 rocket fiberglass shipping tubes which had already been burned at least once in the CAMDS furnace. In all tests except Test #41 the drum was rotated at a constant speed, the controlled variable being the air flow rate through the drum which subsequently passed through the afterburner. For Test #41 the drum of fiberglass was not rotated.

Sampling was performed both in the horizontal duct, approximately four feet before the inlet to the afterburner, and also in the vertical duct, approximately 20 feet after the outlet from the afterburner (see attached schematic). In each duct it was only possible to do one sampling traverse, rather than two traverses at right angles to each other because of sampling equipment space limitations. It was possible, however, to perform a pitot traverse in both directions on the inlet.

Before each test the air flow rate through the system was set by means of a differential pressure draft gauge. A calibration chart for



# SIW

this system was used to determine the draft gauge setting, but since this was only an approximate air flow rate, a pitot traverse at the afterburner inlet sampling point was performed before each test in order to establish a more accurate flow rate value.

The last six tests were performed in inlet-outlet pairs, each pair at approximately the same flow rate, but not simultaneously. The purpose behind this arrangement was to determine whether or not any of the fiberglass was being removed by the afterburner. Test pairs #42,43 and #46,47 showed that the afterburner did remove approximately half of the fiberglass which entered it. Test pair #44,45 showed more fiberglass leaving the afterburner than was entering it. The reason for this can be explained by the fact that this test pair was run at a very high air flow rate. During Test #44 (inlet) large balls of fiberglass were flowing through the duct on account of the large flow rate. These balls of fiberglass were on several occasions caught on the sampling probe, effectively blocking the nozzle. In one instance the nozzle became plugged and in another instance the whole duct became plugged when the probe was in at the furthest point. These circumstances evidently precluded an accurate sample from being collected.

A summary of the results is shown in Table I. Following are also pitot and sampling point layouts and a schematic of the rotary drum-afterburner system.



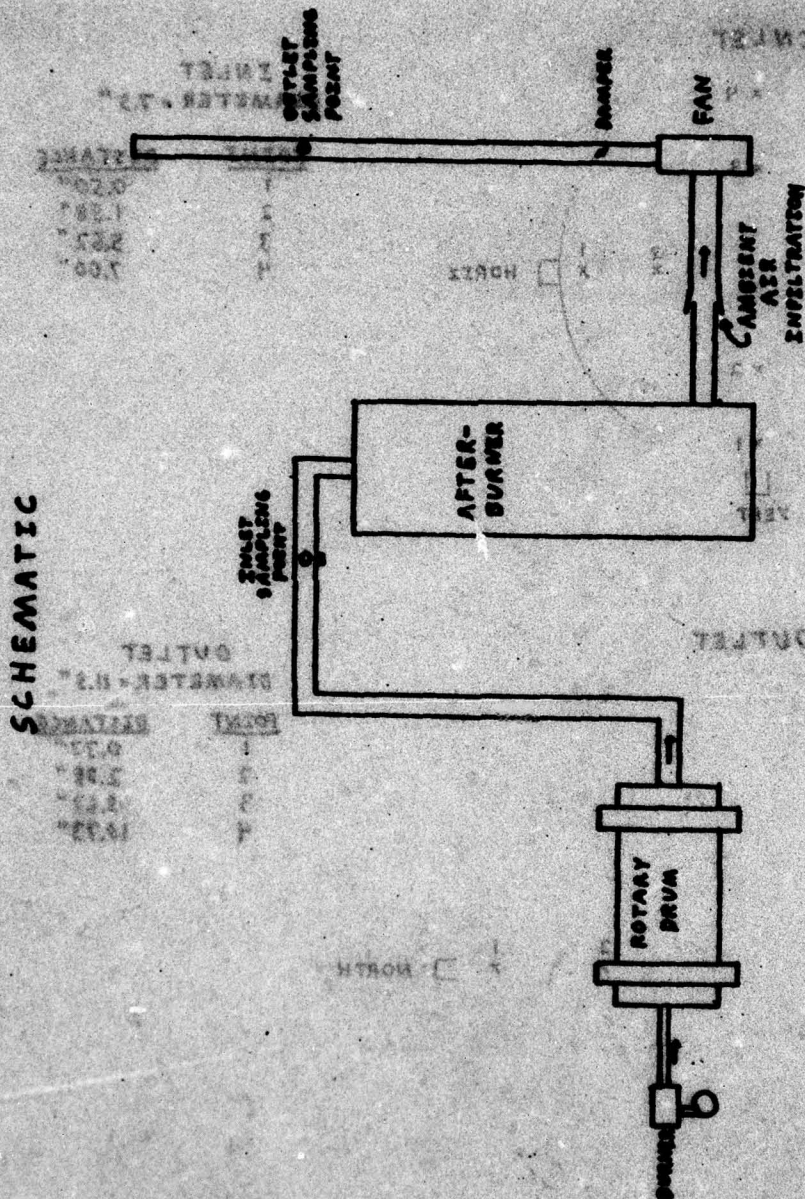
**TABLE I**

Test #	41 Inlet	
Flow rate set point SCFH (Inlet)	14,000	
Measured flow rate SCFH (Inlet)	12,100	
Grains/DSCF	0.00450	
Pounds/Hour	0.00766	
Efficiency %	*	
Test #	42 Inlet	43 Outlet
Flow rate set point SCFH (Inlet)	14,000	14,000
Measured flow rate SCFH (Inlet)	12,100	12,000
Grains/DSCF	6.42	0.405
Pounds/Hour	11.5	5.85
Efficiency %	49.1	
Test #	44 Inlet	45 Outlet
Flow rate set point SCFH (Inlet)	20,000	20,000
Measured flow rate SCFH (Inlet)	27,100	21,000
Grains/DSCF	2.26	0.734
Pounds/Hour	7.49	10.8
Efficiency %	*	Negative
Test #	46 Inlet	47 Inlet
Flow rate set point SCFH (Inlet)	10,000	10,000
Measured flow rate SCFH (Inlet)	10,700	14,700
Grains/DSCF	4.05	9.18
Pounds/Hour	8.93	4.23
Efficiency %	*	32.6



WMS

SCHEMATIC OF THE SYSTEM AND PLYOT TRAVEL



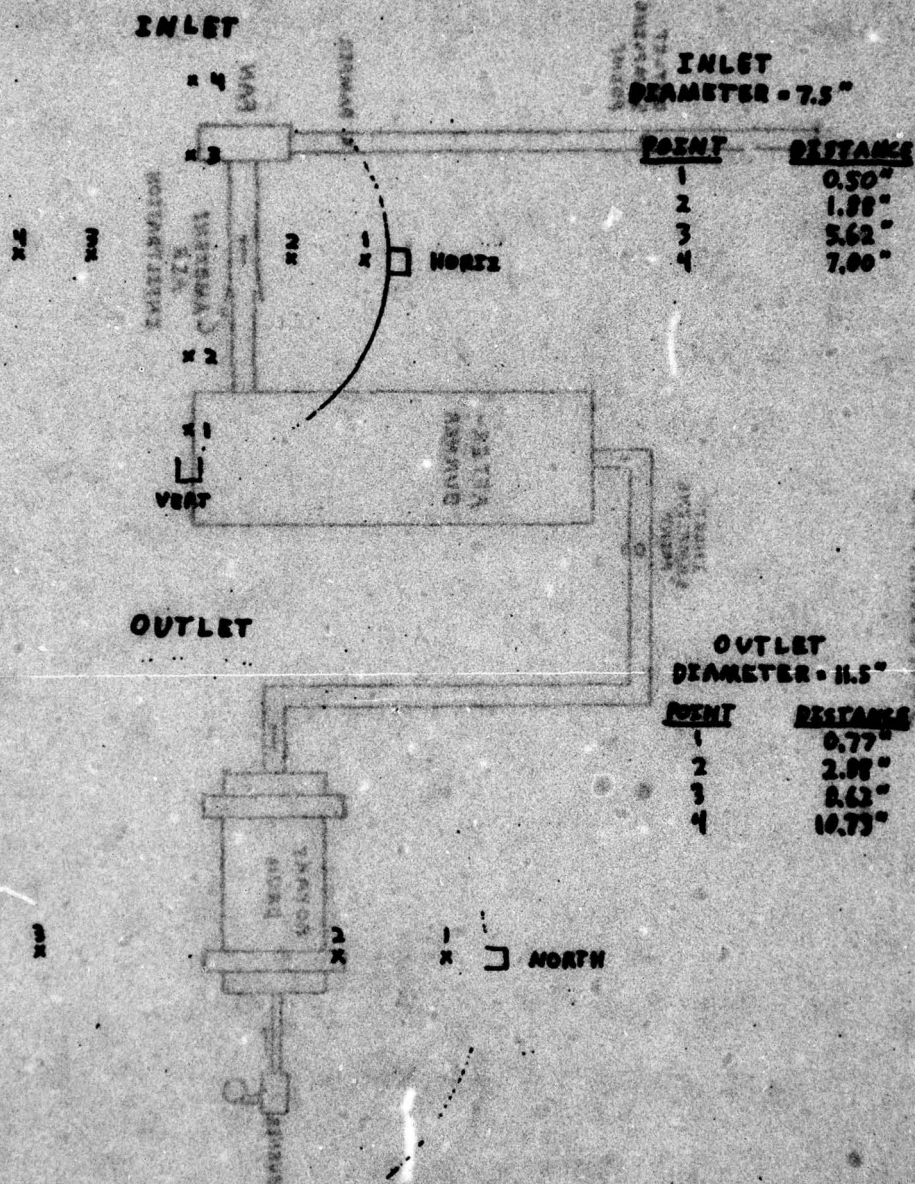
SCHEMATIC

F.W.



# SIW

## SAMPLING POINT AND PILOT TRAVERSE LAYOUT





**Pilot Test  
For  
Slagging Afterburner**

Raw data sheets from the STW Testing, Inc. test report have been removed from this printing. A copy of this volume is available on request to the Program Manager for Demilitarization of Chemical Materiel, AMXDC-T, Aberdeen Proving Ground, MD 21010.

Relativity Specifications

(The specifications have been deleted from this printing. A copy of this material is available on request to the Program Manager for Chemical Demilitarization and Installation Restoration, AMXDC-T, Aberdeen Proving Ground, MD 21010.)



**Slagging Afterburner  
DAAA15-75-C-0004**

Slagging Afterburner  
DAAA15-75-C-0004

For data sheets from the 1975 testing, see test report have been removed from this printing. A copy of this volume is available on request to the Project Manager for Chemical Demilitarization and Installation Restoration, DRCPM-DDD-TM, Aberdeen Proving Ground, MD 21010.

### **Refractory Specifications**

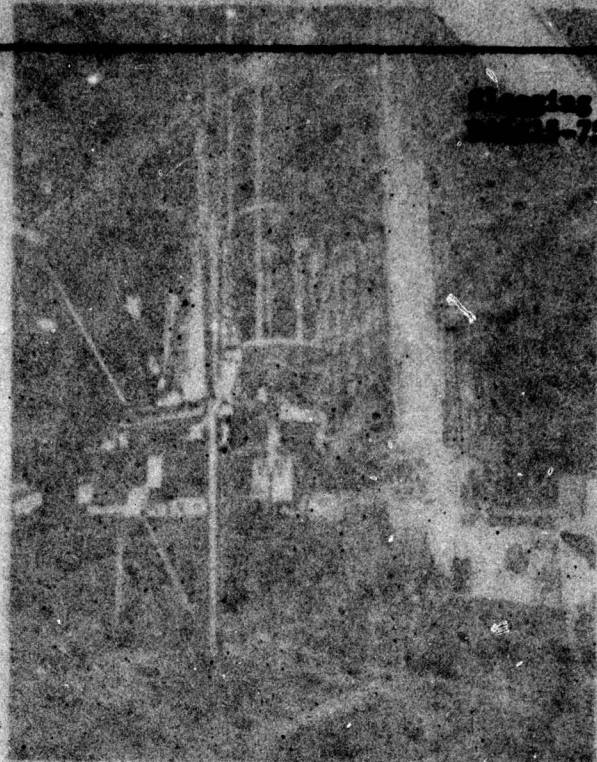
(The specifications have been deleted from this printing.  
A copy of this material is available on request to the Project  
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DRCPM-DDD-TM, Aberdeen Proving Ground, MD 21010.)



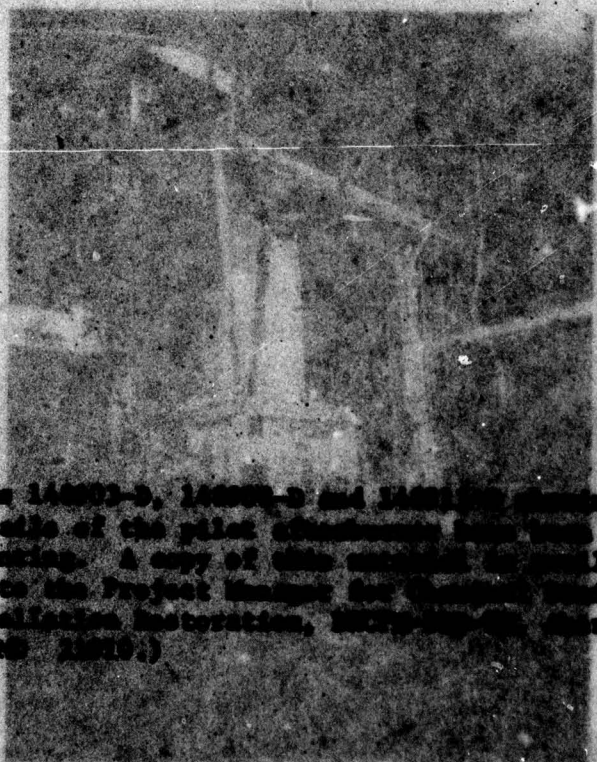
**SURFACE COMBUSTION**

35-21-A

**Blowing Afterburner**  
**DAW-75-C-0084**

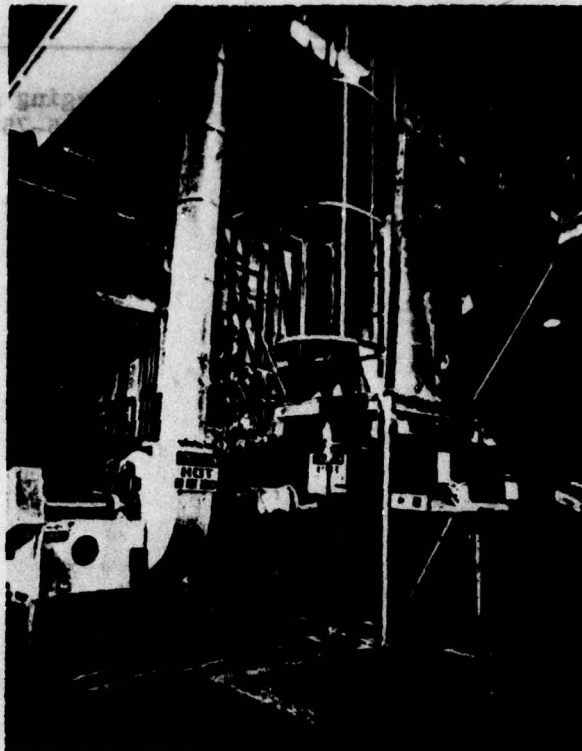


**Pilot Test Facility**  
**Drawings and Photographs**



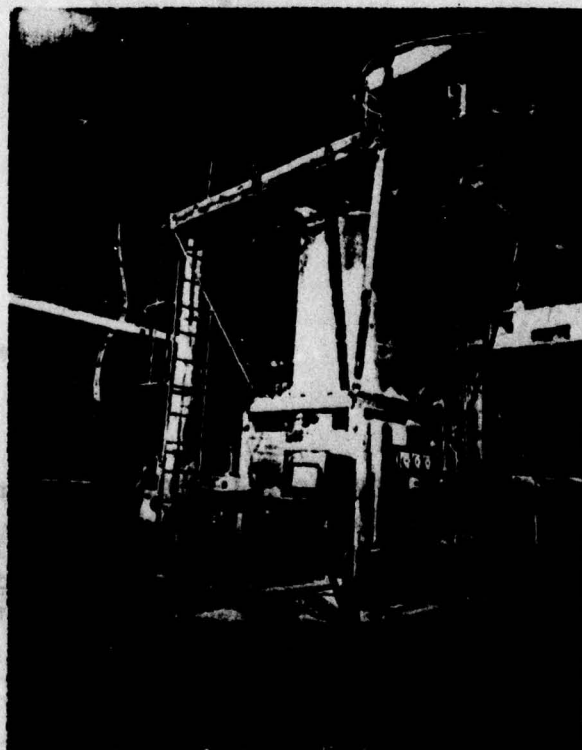
(Drawings 14001-3, 14002-3 and 14003-3 showing construction details of the pilot afterburner have been deleted from this printing. A copy of this manual is available on request to the Project Manager for Chemical Militarization and Installation Restoration, HQRD-40-0, Aberdeen Proving Ground, MD 21015.)





Pilot Test Facility  
Drawings and Photographs

4-16-75



Construction  
Detailed from  
Labels on  
Illustration  
When Proving

(Drawings  
also for  
this part  
request  
and last  
ground.

2012



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(When Data Entered)

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4. TITLE (and Subtitle) Final Demilitarization Plan; Operation of the CAMDS at Tooele Army Depot Inclosure 6 - Deactivation Furnace System Testing		5. TYPE OF REPORT & PERIOD COVERED Final
7. AUTHOR(s)		6. PERFORMING ORG. REPORT NUMBER
8. CONTRACT OR GRANT NUMBER(s)		
9. PERFORMING ORGANIZATION NAME AND ADDRESS Edgewood Arsenal Aberdeen Proving Ground, MD 21010		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE OF THE PROJECT/MANAGER FOR CHEMICAL DEMILITARIZATION AND INSTALLATION RESTORATION ABERDEEN PROVING GROUND, MARYLAND 21010		12. REPORT DATE March 1977
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 130
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		16. DECLASSIFICATION/DOWNGRADING SCHEDULE
18. DISTRIBUTION STATEMENT (of this Report) Approved for Public Release: Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
19. SUPPLEMENTARY NOTES		
20. KEY WORDS (Continue on reverse side if necessary and identify by block number) Chemical Agent/Munition Disposal System Chemical Demilitarization Deactivation Furnace System Thermal Detoxification of Chemical Agents Thermal Deactivation of Explosives Tooele Army Depot, Utah M23 Landmine M48 Initiator Comp B4 Tetryl		
21. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Chemical Agent Munition Disposal System is a prototype facility for the large scale destruction of lethal chemical agents and munitions. This document contains test reports relating to the thermal detoxification of chemical agents and the thermal deactivation of explosives.		

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REPORT DOCUMENTATION PAGE REPORT NUMBER GOVT ACCESSION NO.		READ INSTRUCTIONS REPORT COMPLETING FORM RECIPIENT'S CATALOG NUMBER	
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6. MONITORING AGENCY NAME & ADDRESS (if different from performing organization) 7. DISTRIBUTION STATEMENT (for this report) Approved for Public Release; Distribution Unlimited		8. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 9. REPORT DATE 10. NUMBER OF PAGES 11. SECURITY CLASS. (for this report) UNCLASSIFIED	
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15. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Chemical Agent/Munition Disposal System is a prototype facility for the large scale destruction of lethal chemical agents and munitions. This document contains test reports relating to the thermal detoxification of chemical agents and the thermal detoxification of explosives.			



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